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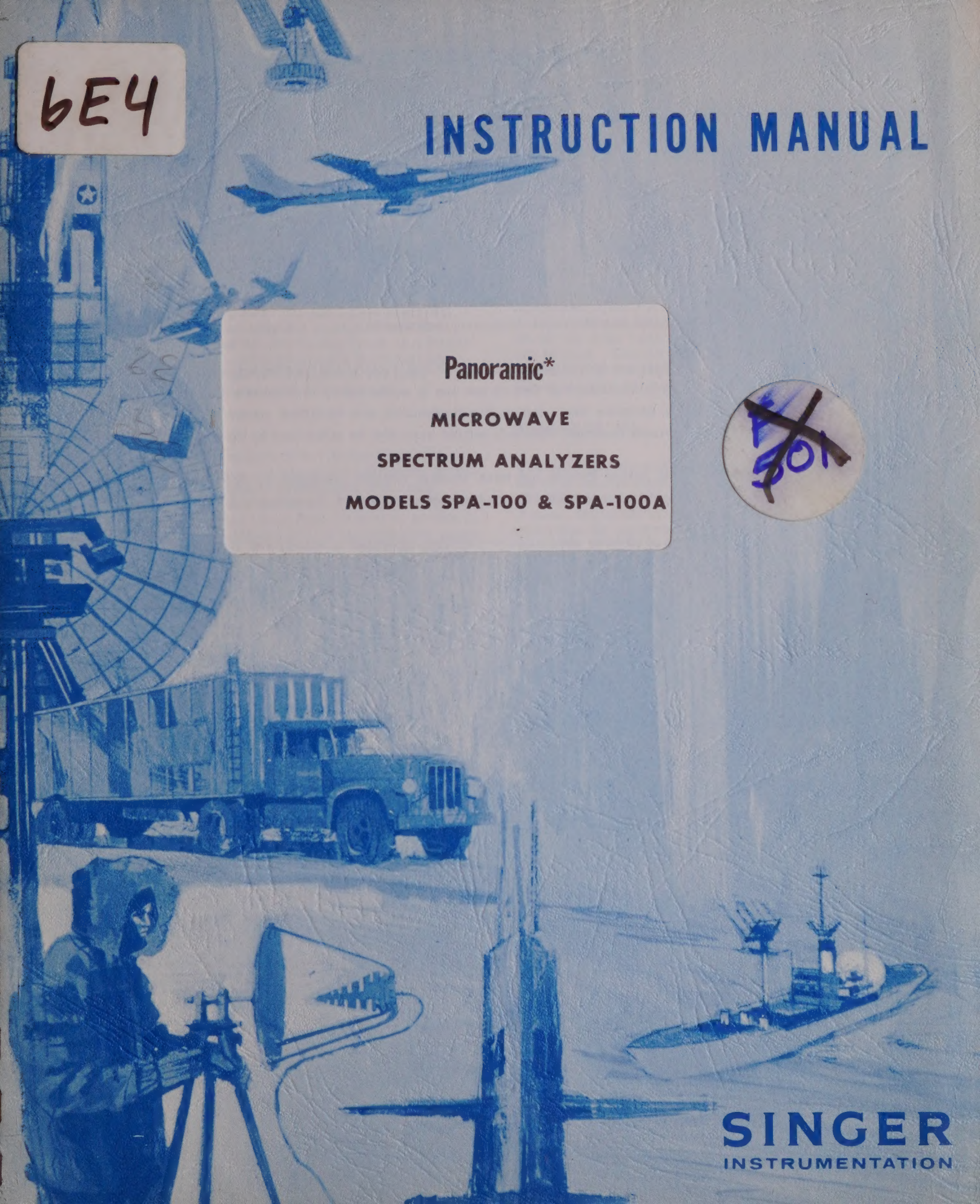
INSTRUCTION MANUAL

Panoramic*

MICROWAVE

SPECTRUM ANALYZERS

MODELS SPA-100 & SPA-100A



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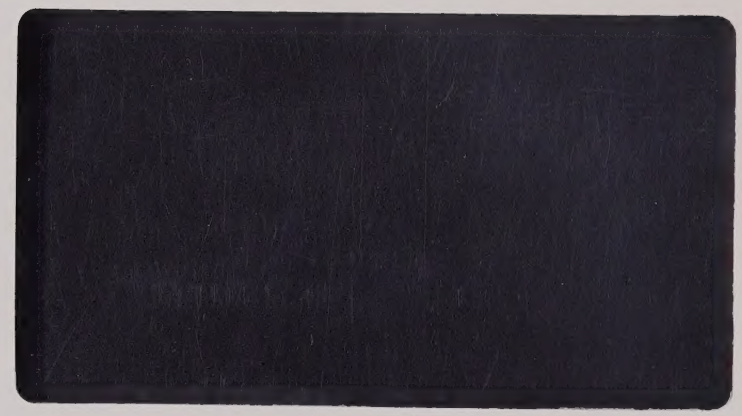

INSTRUCTION MANUAL

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Panoramic*

MICROWAVE

SPECTRUM ANALYZERS

MODELS SPA-100 & SPA-100A

THIS HANDBOOK IS TO BE USED
WITH EQUIPMENT SERIAL NUMBERED
U30467 AND UP

SINGER
INSTRUMENTATION

Precision electrical and electronic instruments for measurement

emc — EMPIRE* — Gertsch* — Panoramic* — Sensitive Research*

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Sensitive Research Electrical Indicating Instruments.....2 years
Other Electrical and Electronic Measuring Instruments.....1 year

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1. Model or Type
2. Serial Number
3. Description of trouble(2)
4. Test instruments used
5. Approximate date instrument was placed in operation
6. Approximate number of hours of use
7. Has maintenance action been previously requested?
8. Other comments

Upon receipt of this information our Service Department will send you service data or shipping instructions. Upon receipt of shipping instructions forward the instrument to the factory prepaid. If requested, an estimate of charges will be made before work begins.

(1) Contact Metrics Division, 915 Pembroke St., Bridgeport, Connecticut for *Empire*, *Panoramic*, and *Sensitive Research* instruments.
Contact Metrics Division, 3211 S. LaCienega Blvd., Los Angeles, California for *Gertsch* instruments.
Contact Metrics Division, 7338 Varna Ave., N. Hollywood, California for *EMC* instruments.

(2) Include data on symptoms, measurements taken, suspected location of trouble, maintenance action taken, and any other relevant data.

MODEL SPA-100 AND MODEL SPA-100A
PANORAMIC® MICROWAVE SPECTRUM ANALYZER

Preface to Instruction Manual

GENERAL.

The two technical manuals contained in this handbook cover all of the equipment necessary to form either a PANORAMIC Model SPA-100 Microwave Spectrum Analyzer, which consists of a Model MF-100 Main Frame and a Model RF-100 Tuning Head; or a PANORAMIC Model SPA-100A Microwave Spectrum Analyzer, which consists of a Model MF-100 Main Frame and a Model RF-100A Tuning Head.

DESCRIPTION.

The PANORAMIC Models SPA-100 and SPA-100A Microwave Spectrum Analyzers are extremely versatile universal broadband instruments with highly accurate calibration capabilities. The Model SPA-100 covers the frequency range from 10 MHz to 40 GHz in six bands while the Model SPA-100A covers the range from 0.94 to 40 GHz in five bands. The only difference between the two units is that the former includes a unique up-converter which translates the 10-MHz to 1-GHz input frequency range to the 2.5 to 3.5 GHz band, thereby permitting full 100-MHz dispersion -- even down to 10 MHz.

The modular construction feature of the latest of the SPA-series of spectrum analyzers affords the user extension of the equipment capability to 3-GHz dispersion by the addition of the Model RF-3000 Swept Front End at a later date.

The tuning heads, which are inserted into a front panel opening in the main frame assembly and screwed into place, incorporate the r-f circuitry necessary to convert the applied r-f signal under analysis to the center of the display unit's wideband i-f amplifier passband. Highly efficient first mixers and an extremely stable levelled first local oscillator output provides high sensitivities and gain stability without the need for phase locking. The unique up-converter within the RF-100 enables the full 100-MHz dispersion range to be employed, even when operating at the low end of the analyzer frequency range. Optional external mixers are available for use with both Model RF-100 and RF-100A when operating in the 11-40 GHz ranges.

The Model MF-100 Main Frame contains the circuitry common to the latest of the SPA-series of spectrum analyzers. This solid-state assembly incorporates state-of-the-art wideband and variable bandwidth narrowband i-f amplifiers, a combination wide and narrow swept second local oscillator, a sequential-detection logarithmic i-f amplifier as well as internal marker oscillator, sweep and synchronization circuitry.

Calibrated dispersions of zero (for receiver operation or time-domain analysis) and 10 kHz to 100 MHz, sweep times from 100 microseconds to 10 seconds, resolution bandwidths from 1 kHz to 1 MHz, i-f attenuation from 0 to 69 dB in 1-dB increments as well as calibrated linear, power (square-law) and 60-dB log scale truly make these instruments universal devices. Remote programming capabilities and auxiliary x-y and predetected 60-MHz outputs permit signal analysis from remote locations.

HANDBOOK USE.

Two technical manuals are provided under this cover: the first manual covers both tuning heads, Models RF-100 and RF-100A; and the other covers the Main Frame, Model MF-100. Section I of each manual describes the purpose and use of each unit and also provides, in tabulated form, the unit specifications. Because the tuning head performs the front-end function and determines system operation, those specifications which relate to overall system capabilities are covered in the tuning head manual; while only those specifications covering the presentation are covered in the Main Frame manual.

The procedures for proper operation of the Spectrum Analyzer are dependent upon the associated tuning head. Therefore, the operating procedures are contained in the Operation Section (Section II) of the tuning head manual.

Section III of the Model RF-100 and RF-100A manual covers the theory of operation of both tuning units, for the circuits in each unit are identical, except that Model RF-100 has additional circuitry which is also covered. The Main Frame manual covers all circuitry which follows the generation of the first intermediate frequency, 160 MHz.

Section IV of each manual contains minimum performance standards, component location data, troubleshooting procedures, alignment procedures, and parts removal and replacement procedures. Because of the diversity of tuning head possibilities, procedures for the removal and replacement of the tuning head are provided in the tuning head manual. The procedures covering all other components are covered in the manual housing the components of interest.

Schematic diagrams are provided in Section V of both manuals, and Section VI contains a complete electrical parts list.

WARNING

HIGH VOLTAGE

is used in the operation of this equipment

DEATH ON CONTACT

may result if personnel fail to observe safety precautions

Learn the areas containing high voltage

in each piece of equipment

Be careful not to contact high-voltage connections

when installing or operating this equipment

Before working inside the equipment, turn power

off and ground points of high potential

before touching them

INSTRUCTION MANUAL

Panoramic*

TUNING HEADS

MODELS RF-100 & RF-100A

Instruction Manual No. 110-5080

Serial No. _____

SINGER
INSTRUMENTATION

Precision electrical and electronic instruments for measurement

emc — EMPIRE* — Gertsch* — Panoramic* — Sensitive Research*

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ADDENDUM

for

MODELS RF-100 & RF-100A

I. PURPOSE.

To correct error in parts list.

II. ADDENDUM.

a. In table 6-1, add the following number and name.

74868	Amphenol Corp. Amphenol Rf Division Danbury, Conn.

b. In table 6-2, change the "Mfr's Code" of K2 from 74970 to 74868.

Addendum No. 577

ADDENDUM

for

MODELS RF-100 & RF-100A

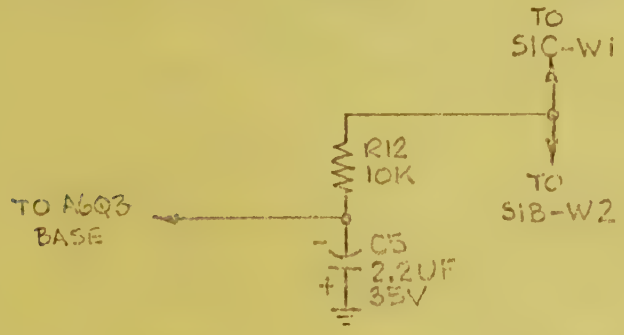
(Effective on equipment serial numbered U30540, U30775 thru U30778, U30780 thru U30783 and U30785 and up.)

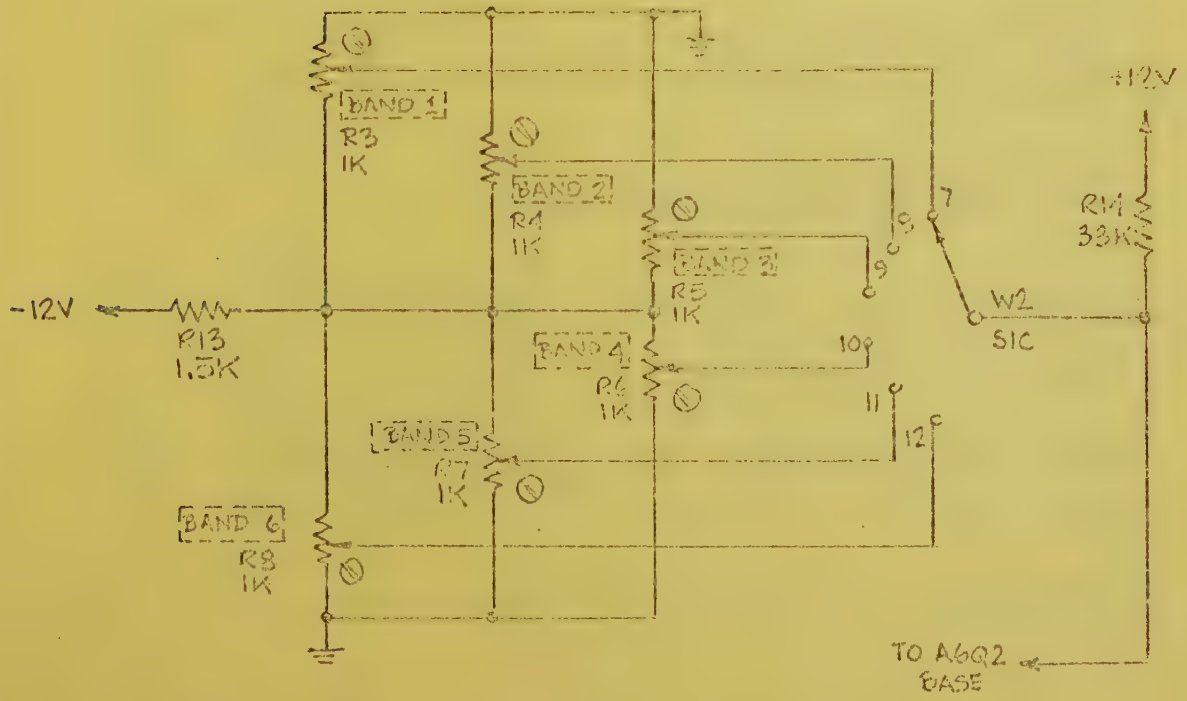
I. PURPOSE.

To improve operation of triode oscillator.

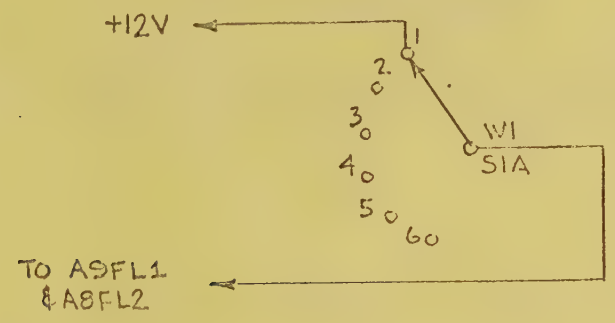
II. ADDENDUM.

a. In figure 5-3, delete resistor A6R4 (10K) and its -12V supply and incorporate the changes shown below:





b. In figure 5-1, delete resistor A6R4 (10K) and its -12V supply, incorporate the two changes shown above and then incorporate the additional change shown below:



c. In table 6-1, add:

06751	Semcor Div. of Components, Inc. Phoenix, Arizona

d. In table 6-2, delete the entry for A6R4 and incorporate the following:

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
C5	CAPACITOR, FIXED, ELECTROLYTIC, 2.2UF, 35V SINGER P/N 556146-506	CS13BF225K	06751	1
R12	RESISTOR, FIXED, COMP., 10K OHMS, PORM 5 PCT, 1/4W SINGER P/N 151-1002-103J	CB1035	01121	1
R13	RESISTOR, FIXED, COMP., 1.5K OHMS, PORM 5 PCT, 1/4W SINGER P/N 151-1002-152J	CB1525	01121	1
R14	RESISTOR, FIXED, COMP., 33K OHMS, PORM 5 PCT, 1/4W SINGER P/N 151-1002-333J	CB3335	01121	1
A6	LEVEL AMPLIFIER ASSY	103-1576-002	16665	1
A2R1	SAME AS R12			
A5R3	SAME AS R12			

Addendum No. 595

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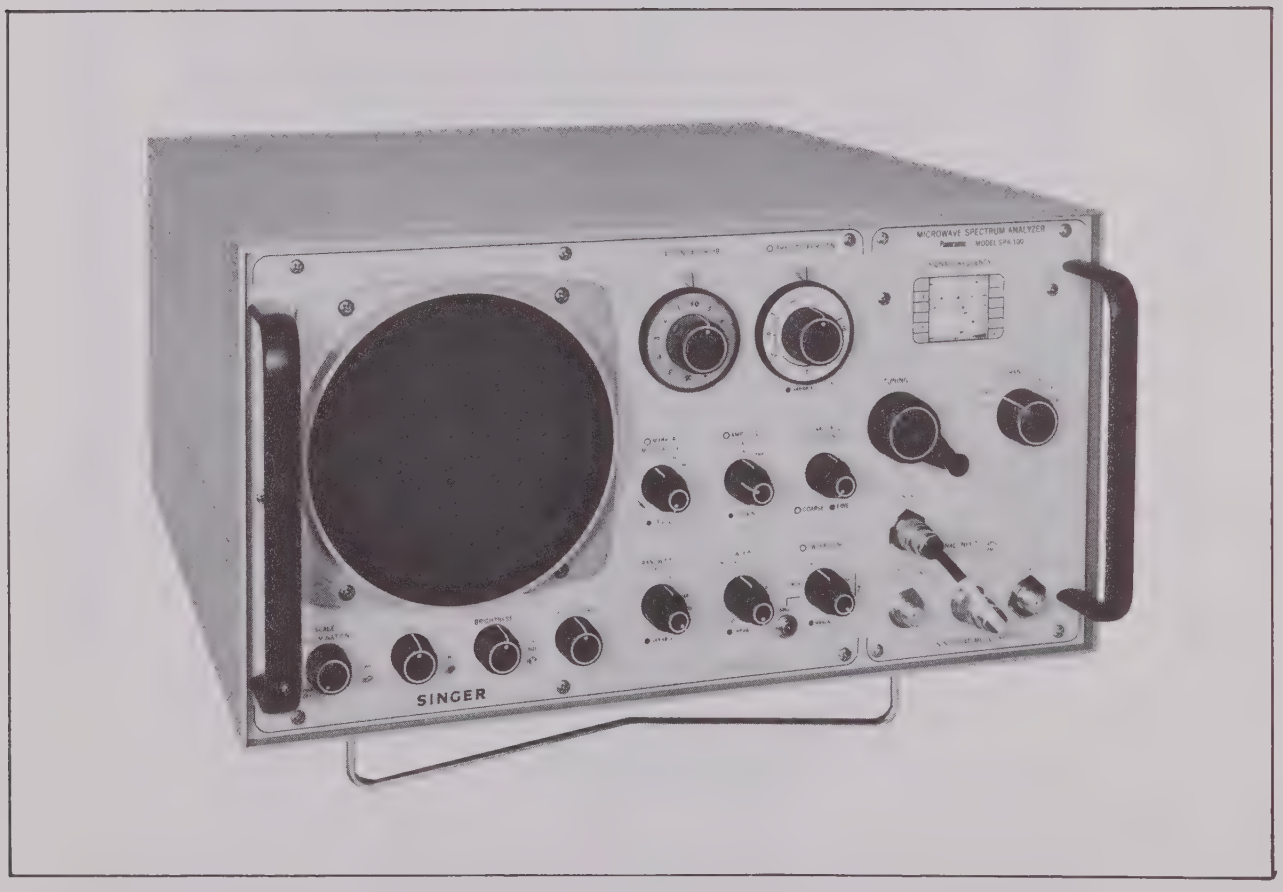

Figure 1-1. Model RF-100 Tuning Head Installed in Model MF-100 Main Frame

SECTION I
INTRODUCTION

1-1. SCOPE OF MANUAL.

1-2. This manual provides general information and operating instructions for the PANORAMIC* Models SPA-100 and SPA-100A (see figure 1-1) Microwave Spectrum Analyzers, manufactured by The Singer Company - Metrics Division. This manual also includes the theory of operation and maintenance data for the front end portion of the analyzers (Model RF-100 Tuning Head for the SPA-100 and Model RF-100A Tuning Head for the SPA-100A).

Note

The general information, theory of operation and maintenance instructions for the Model MF-100 Main Frame portion of the spectrum analyzer is contained in the manual at the back half of this volume.

1-3. The information contained in this handbook reflects the standard Models RF-100 and RF-100A Tuning Heads (hereafter referred to as the RF-100 and RF-100A, respectively) and Models SPA-100 and SPA-100A Microwave Spectrum Analyzers (hereafter referred to as the SPA-100 and SPA-100A, respectively). Differences in equipment configuration, components, specifications and performance resulting from customer application requirements and/or The Singer Company's continuous product improvement program are described in addendum sheets.

1-4. PURPOSE AND USE OF THE EQUIPMENT.

1-5. The RF-100 and RF-100A are multiband tunable front ends which, in conjunction with a Model MF-100 Main Frame (hereafter referred to as the Main Frame) enables the user to visually examine either the amplitude-frequency characteristics or amplitude-time characteristics of applied r-f signals. These instruments are extremely useful for measuring and analyzing various types of r-f signals. Some typical applications of the equipment are listed below:

a. Dynamic performance analysis of oscillators, generators and transmitters.

b. Spectrum monitoring of communications channels and radar frequencies.

c. Analyzing pulsed signals.

d. Analyzing spectra associated with amplitude-, frequency- and pulse-modulated signals.

e. Direct reading of power peak and null frequencies.

f. Microwave equipment malfunction studies (e.g., spurious signals, instabilities, microphonics, etc.).

g. Factory calibration of production r-f equipment.

h. Harmonic and other out-of-band measurements.

i. Examination of cw signal drift, incidental fm and squegging.

j. Examining dynamic operating characteristics of microwave tubes and devices.

k. Checking for r-f radiation and leakage.

l. Determining the presence and frequency of r-f signals.

m. Use as a sensitive receiver to measure characteristics of microwave components or circuits (e.g., insertion loss and VSWR measurements).

n. Noise spectra studies.

1-6. Inquiries are invited regarding special applications of the SPA-100 and/or SPA-100A to particular customer requirements. Such inquiries should be directed to the Applications Engineering Department.

1-7. SUPPLIED AND OPTIONALLY AVAILABLE ACCESSORIES.

1-8. Both the SPA-100 and SPA-100A are shipped complete and are ready for use upon receipt. The only supplied accessory is a short patch cable (for use with the SPA-100) which is used to interconnect the SIGNAL INPUT 1-11 GHz and UP CONVERTER OUTPUT jacks of the RF-100 when the SPA-100 is employed in the 10 MHz to 1 GHz band. Optionally available accessories, which are supplied only when

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specifically ordered, are listed and described in table 1-1.

1-9. SPECIFICATIONS.

1-10. The electrical and physical specifications of the SPA-100 and SPA-100A are listed in table 1-2.

1-11. ELECTRON TUBE, TRANSISTOR AND DIODE COMPLEMENT.

1-12. The types and functions of the entire complement of electron tubes, transistors and diodes employed in both the RF-100 and RF-100A are listed in table 1-3.

TABLE 1-1. OPTIONALLY AVAILABLE ACCESSORIES

Nomenclature	Function
Model AT-100 R-f Attenuator Set	A set of three coaxial attenuators (10 dB ±1.25 dB, 20 dB ±1.5 dB and 30 dB ±2 dB) employed to attenuate r-f signals within the 10 MHz to 11 GHz frequency band. These attenuators can be connected in series to provide up to 60-dB of attenuation in 10-dB steps.
Model FL-100 Low-pass Filter	Low-pass filter which, when connected to the RF-100 SIGNAL INPUT 0.01-1 GHz jack during band 1 operation, attenuates the 2.5-GHz local oscillator feedthrough from the jack by 60 db.
Model K_u-100 Waveguide Mixer*	External waveguide mixer (mates with UG-419/U flange) for signals between 11 and 18 GHz.
Model K-100 Waveguide Mixer*	External waveguide mixer (mates with UG-595/U flange) for signals between 18 and 26 GHz.
Model K_a-100 Waveguide Mixer*	External waveguide mixer (mates with UG-599/U flange) for signals between 26 and 40 GHz.
CMF-100 Front Panel Cover	Protective cover for equipment front panel; provides storage space for accessories that are not being used.
Model RM-100 Rack Mounting Ears	Permits mounting of equipment in a standard 19-inch rack.
Model RM-101 Rack Mounting Ears and Slides	Permits slide-mounting of equipment in a standard 19-inch rack.
Connector and Hood (Singer Part Nos. 556146-750 and -758; Continental Connector Corp. Part Nos. SM41-20PGD and -20H-1)	Eleven-pin connector which mates with auxiliary input/output connector J1 on rear panel of Main Frame.
Coaxial Connector (Singer Part No. 556147-019; Sealectro Corp. Part No. 50-11-001)	Coaxial connector which mates with auxiliary 60 MHz OUTPUT connector J11 on rear panel of Main Frame.

*36-inch coaxial cable furnished with one or more mixer(s) for coupling to RF-100 or RF-100A SIGNAL INPUT 11-40 GHz jack

TABLE 1-2. SPECIFICATIONS

Parameter	Specification
Frequency range	10 MHz to 40 GHz in 6 bands (RF-100) 0.94 to 40 GHz in 5 bands (RF-100A).
Frequency accuracy	±1% of local oscillator frequency

(Cont')

TABLE 1-2. SPECIFICATIONS (Cont'd)

Parameter	Specification		
Sensitivity[1]	Frequency range	L.O. harmonic	Minimum sensitivity
	10 MHz to 1 GHz[2]	1st	-90 dBm
	0.94 to 3.5 GHz	1st	-110 dBm
	3.2 to 11 GHz	3rd	-105 dBm
	11 to 18 GHz[3]	5th	-90 dBm
	18 to 26 GHz[3]	7th	-80 dBm
	26 to 40 GHz[3]	11th	-75 dBm
First local oscillator:			
Type	Ceramic triode tunable from 1.1 to 3.7 GHz		
Incidental FM	1 kHz peak-to-peak, maximum		
Dispersion:			
Range	Nine calibrated dispersions from 10 kHz to 100 MHz in 1-3-10 sequence (100-MHz dispersion operative in 10 MHz to 1 GHz band of RF-100); continuously adjustable between steps. Zero dispersion capability for receiver or synchroscope operation.		
Accuracy	±5%		
Phase lock	Stable first local oscillator with low incidental FM provides jitter-free display		
Markers (auto calibration):			
Internal	160-MHz center frequency marker either alone or with selectable 1- and 10-MHz sideband modulation capability		
External	1-kHz to 1-MHz sideband modulation capability of internal 160-MHz center frequency marker		
Signal attenuation:			
R-f	0 to 60 dB in 10-dB steps through the use of optionally available external attenuators (10 MHz to 11 GHz)		
I-f	0 to 69 dB in 1-dB steps; accuracy of ±0.05 dB/dB		
Image separation	320 MHz		
Bandwidths:			
Fixed	Six calibrated steps of 1 kHz, 3 kHz, 10 kHz, 30 kHz, 100 kHz, 1 MHz and AUTO (automatically selects bandwidth for optimum CW resolution)		

Notes: 1 Sensitivity defined as signal plus noise equal to twice noise (S+N=2N) at 1 kHz bandwidth, linear display.

2 SPA-100 only.

3 In conjunction with optionally available waveguide mixers.

(Cont'd)

TABLE 1-2. SPECIFICATIONS (Cont'd)

Parameter	Specification
Bandwidths: (Cont'd)	
Variable	1 to 100 kHz, continuously adjustable
Video filter	Tracked with variable bandwidth, independently adjustable in calibrated bandwidth step positions
Variable i-f gain	20 dB, minimum
Amplitude scales:	
Logarithmic	60 dB (on screen); accuracy ±2 dB
Linear	Relative voltage; accuracy ±3% of full scale
Power (square law)	Relative power; accuracy ±5% of full scale
CRT	5ADP31M
Graticule	7.5 cm high x 10 cm wide
Sweep modes	Internal, external, manual or single sweep
External sweep input	-5 to +5 volts for full sweep
Sweep time	Eleven calibrated steps from 10 usec/division to 1 second/division in 1-3-10 sequence, continuously adjustable between steps; vernier extends slowest time to at least 3 seconds/division
Spectrum analyzer mode	3 milliseconds/division to 1 second/division
Synchroscope mode	10 usec/division to 1 millisecond/division
Synchronization	Free-running, line, internal or external
External sync level	+3 volts, minimum
Intensifier	Baseline clipper for brighter display of narrow pulses
Auxiliary outputs:	
I-f patch	160 MHz
Vertical output	0 to +1 volt (nominal); source impedance 1000 ohms
Horizontal output	-0.5 to +0.5 volts (nominal); source impedance 1000 ohms
Predetected 60 MHz output	5-MHz bandwidth
Power requirements	115 or 230 vac (±10%), 47 to 440 Hz, 80 watts
Size	16-3/4" wide x 8-23/32" high x 19-1/2" deep
Weight	65 pounds

TABLE 1-3. ELECTRON TUBE, TRANSISTOR AND CRYSTAL DIODE COMPLEMENT

Reference Symbol Number	Electron Tube, Transistor or Diode Type	Function
Main Chassis		
CR1	1N3011B	Voltage regulator
CR2	132-0220-001 (Singer-Metrics)	Voltage regulator
1-11 GHz Mixer A1		
CR1	1N1132	First mixer
160-MHz Preamplifier A2		
Q1	FT-45 (Fairchild)	160-MHz amplifier
Triode Oscillator A3		
V1	Y1610 (GE-modified)	First local oscillator
160-MHz Preamplifier A5		
Q1	FT-45 (Fairchild)	160-MHz amplifier
Level Amplifier A6		
Q1	2N3440	First local oscillator cathode bias regulator
Q2 and Q3	2N3694	Emitter-coupled difference amplifier
0.01-1 GHz Mixer A7*		
CR1	MA417 (Microwave Assoc)	First mixer
Buffer Amplifier/Frequency Multiplier A8*		
CR1	HPA-0112 (HP Assoc)	Frequency multiplier
Q1	2N4427	Buffer amplifier
104.167-MHz Oscillator A9*		
A1Q1	2N3563	104.167-MHz oscillator
A1Q2	2N3642	Buffer amplifier
A2Q1	2N3866	Frequency tripler

*Employed only in RF-100 Tuning Head

SECTION II
OPERATION

2-1. GENERAL.

2-2. This section contains instructions for the installation and operation of both the SPA-100 and SPA-100A. It is strongly recommended that the operator become thoroughly familiar with the material in this section before attempting to operate the equipment. Failure to do so may compromise the great versatility that has been engineered into the instrument.

2-3. INSTALLATION.

2-4. The SPA-100 or SPA-100A is shipped complete and is ready for use upon receipt. After the equipment has been unpacked, check the contents of all shipping containers against the packing invoice to ascertain that the order is complete.

2-5. INSPECTION. Examine the equipment for indications of damage which may have occurred during shipment. Check all front panel controls for freedom of movement, full travel and positive-detent locking. Note any evidence indicating that the equipment has sustained a severe mechanical shock. Check the condition of all accessories furnished as part of the order. Ascertain that the supplied i-f patch cable is connected between the rear panel IF OUTPUT and IF INPUT jacks and that interlock plug P9 is properly mated to rear panel AUXILIARY MODULE connector J2.

2-6. BENCH MOUNTING. The SPA-100 or SPA-100A should be mounted on a sturdy, vibration-free surface. Carefully slide the equipment so that its front panel is parallel to, and a few inches from, the edge of the bench.

2-7. RACK MOUNTING. To install the equipment in a standard 19-inch rack, proceed as directed below.

CAUTION

Before installing the equipment into the rack, ascertain that the 115V/230V line switch located on the rear panel of the Main Frame is properly set. Refer to paragraph 2-11.

a. Secure the rack mounting ears to the sides of the equipment (see figure 2-1). For conventional rack mounting, provide an angle bracket at the rear of the rack to support the weight at the rear of the equipment.

b. If the equipment is to be slide mounted, secure the slides to both the sides of the equipment (see figure 2-1) as well as the rack walls.

c. Install the equipment into the rack and secure the rack mounting ears to the Main Frame. Note that there should be a free flow of air around the equipment.

2-8. OPERATING CONTROLS, INDICATORS AND CONNECTORS.

2-9. All controls, indicators and connectors necessary for the operation of the SPA-100 and SPA 100A are located on the equipment front and rear panels as illustrated in figure 2-2; their functions are described in table 2-1.

TABLE 2-1. OPERATING CONTROLS, INDICATORS AND CONNECTORS

Control, Indicator or Connector	Figure 2-2 Index Number	Function
MARKER LEVEL control	1	Permits the operator to adjust the level of the selected marker display on the CRT. The marker may be unmodulated, modulated by internal circuitry to provide either 1- or 10-MHz sidebands or modulated by an external source. When the control is rotated fully ccw to OFF, the marker generation circuitry is disabled.
MARKER MODULATION switch	2	Permits the operator to select a marker, as follows: EXT - Center frequency marker is modulated by an external signal source to provide sidebands at

(Cont'd)

TABLE 2-1. OPERATING CONTROLS, INDICATORS AND CONNECTORS (Cont'd)

Control, Indicator or Connector	Figure 2-2 Index Number	Function
MARKER MODULATION switch (Cont'd)		frequency increments determined by the source output frequency. OFF - Unmodulated internal center frequency marker is displayed on the CRT. 10 MHz - Center frequency marker is modulated by an internal oscillator to provide sidebands at 10-MHz intervals. 1 MHz - Center frequency marker is modulated by an internal oscillator to provide sidebands at 1-MHz intervals.
IF ATTENUATOR switches	3	Permits attenuation (0 to 69 dB in 1-dB steps) of the i-f input to the Main Frame.
AMPLITUDE SCALE switch	4	Enables the operator to select a 60-dB logarithmic display (LOG), linear display (LIN) or a power display (PWR).
IF GAIN control	5	Adjusts Main Frame i-f gain to enable calibration of the display against a reference input signal.
FREQ DISPERSION switch	6	Selects the dispersion of the display presented on the CRT.
FREQ DISPERSION VARIABLE control	7	Vernier control which permits the operator to reduce the dispersion selected by the setting of the FREQ DISPERSION switch, thereby expanding the presentation for closer signal examination. When the control is rotated fully clockwise to CAL, the display dispersion is that indicated by the setting of the FREQ DISPERSION switch.
SIGNAL FREQ POSITION f_o COARSE control	8	Enables the operator to place the center frequency marker at the f_o vertical line of the graticule. This control is effective for all settings of the FREQ DISPERSION switch.
SIGNAL FREQ POSITION f_o FINE control	9	Vernier adjustment which, in conjunction with the SIGNAL FREQ POSITION f_o COARSE control, enables the operator to place the center frequency marker at the f_o vertical line of the graticule. This control is effective for all settings of the FREQ DISPERSION switch except the 10 MHz/DIV, 3 MHz/DIV and 1 MHz/DIV positions.
SIGNAL FREQUENCY GHz dial	10	Indicates the center frequency of the "window" to which the spectrum analyzer is tuned. The index pointer indicates the proper frequency scale to be read.
SIGNAL FREQUENCY TUNING control	11	Tunes the spectrum analyzer to the desired signal input frequency.

(Cont'd)

TABLE 2-1. OPERATING CONTROLS, INDICATORS AND CONNECTORS (Cont'd)

Control, Indicator or Connector	Figure 2-2 Index Number	Function
SIGNAL FREQUENCY RANGE switch	12	Permits the operator to select the tuning band compatible with the frequency of the applied signal under analysis. The frequency range of these bands are listed below 0.01 to 1 GHz* 0.94 to 3.5 GHz 3.2 to 11 GHz 11 to 18 GHz 18 to 26 GHz 26 to 40 GHz
UP CONVERTER OUTPUT jack*	13	Provides the up-converted output of low frequency (10 MHz to 1 GHz) signals for application to the SIGNAL INPUT 1-11 GHz jack. The frequency range of these up-converted signals is between 2.51 and 3.5 GHz.
SIGNAL INPUT 11-40 GHz jack	14	Connector which simultaneously couples the local oscillator output to, and the first i-f output from, external waveguide mixers.
SIGNAL INPUT 1-11 GHz jack	15	Connector which accepts applied signals within the frequency range from 1 to 11 GHz. When the SPA-100 is operated in the .01-1 GHz band, this connector accepts the up-converted signal from the UP CONVERTER OUTPUT jack.
SIGNAL INPUT .01-1 GHz jack*	16	Connector which accepts applied signals within the frequency range from 10 MHz to 1 GHz.
SWEEP/SYNC switch	17	Permits the operator to select the desired sweep mode as detailed below. SINGLE (black) sweep - Single sweep is initiated by the momentary depression of the SINGLE pushbutton switch. MAN (black) sweep - Sweep position determined by the MANUAL control. EXT (black) sweep - Sweep determined by an externally generated signal applied to rear panel connector J1-E. INT (black) sweep - Sweep is free-running. EXT (red) sync - Sweep is triggered by an externally generated signal applied to rear panel connector J1-D. INT (red) sync - Sweep is triggered by detected video signal. LINE USE (black) - Sweep is synchronized to power line frequency. LINE CAL (black) - Employed when calibrating the video circuitry during maintenance operations and to indicate the sweep time when the SWEEP VARIABLE control is not set fully clockwise to CAL.

*SPA-100 only

(Cont'd)

TABLE 2-1. OPERATING CONTROLS, INDICATORS AND CONNECTORS (Cont'd)

Control, Indicator or Connector	Figure 2-2 Index Number	Function
MANUAL control	18	Permits manual scanning of the displayed spectrum. This control is operative only when the SWEEP/SYNC switch is set to MAN.
SINGLE pushbutton switch	19	Initiates a single sweep when momentarily depressed. This switch is operative only when the SWEEP/SYNC switch is set to SINGLE.
SWEEP switch	20	Permits the operator to select any one of eleven calibrated sweep times (from 10 microseconds per division to 1 second per division in a 1-3-10 sequence).
SWEEP VARIABLE control	21	Permits vernier increasing of the selected sweep time up to at least 30 seconds.
BANDWIDTH switch	22	Enables the operator to select any one of six calibrated i-f bandwidths (1 kHz to 1 MHz), a continuously adjustable i-f bandwidth from 1 to 100 kHz (VAR) and an automatically selected i-f bandwidth (AUTO) for proper resolution of displayed signals.
BANDWIDTH VARIABLE control	23	Provides continuous uncalibrated adjustment of the i-f and video bandwidth between 1 and 100 kHz when the BANDWIDTH switch is set to VAR; provides independent video filtering for BANDWIDTH switch settings of 1, 3, 10, 30 and 100 kHz and AUTO.
INTENSIFIER control	24	Allows intensification of displayed video pulses while blanking baseline and low-level noise.
H SIZE screwdriver control	25	Adjusts length of CRT trace.
BRIGHTNESS control	26	Adjusts the intensity of the CRT display.
H POS screwdriver control	27	Adjusts the horizontal positioning of the trace.
FOCUS control	28	Permits focusing of the CRT display.
V POS screwdriver control	29	Adjusts the vertical positioning of the trace.
SCALE ILLUMINATION control and switch	30	Control adjusts CRT graticule illumination. When control is set fully counterclockwise to PWR OFF, equipment is de-energized.
CRT display	31	Cathode ray tube display with a calibrated graticule scale having 10 horizontal and seven vertical divisions.
60 MHz OUTPUT jack	Rear Panel	Connector which couples predetected 60-MHz i-f signal to auxiliary test equipment.
IF OUTPUT and IF INPUT jacks	Rear Panel	Connectors which couple the 160-MHz output of the installed tuning head to the i-f circuitry within the Main Frame via a short patch cable.
AUXILIARY MODULE connector J2 and shorting plug P9	Rear Panel	Provides the necessary interlocks for connection to accessory modules such as the RF-3000.

(Cont'd)

TABLE 2-1. OPERATING CONTROLS, INDICATORS AND CONNECTORS (Cont'd)

Control, Indicator or Connector	Figure 2-2 Index Number	Function
Auxiliary connector J1	Rear Panel	Connector which couples horizontal and vertical outputs from the Main Frame to accessory recording instruments and couples externally generated sync, sweep signals and marker modulation inputs to the Main Frame.
+300, +100, +12, GND and -12 test points	Rear Panel	Provides accessible test points for monitoring internally developed power supply voltage levels.
F1 and F2 fuseholders	Rear Panel	House line protective fuses.
115V/230V switch	Rear Panel	Enables the equipment to operate from either 115-volt or 230-volt power lines.

Notes: 1. Do not use sweep times faster than 3 milliseconds per division when the FREQ DISPERSION switch is set to 1 MHz/DIV, 3 MHz/DIV or 10 MHz/DIV.

2. The preferred control settings for synchroscope operation are screened on the Main Frame front panel in red.

2-10. POWER APPLICATION AND PRELIMINARY ADJUSTMENTS.

2-11. POWER APPLICATION. The SPA-100 and the SPA-100A are designed to operate from either a 115- or 230-volt (±10%), 47- to 440-Hz power line and draws approximately 80 watts. To couple the equipment to line power, proceed as directed in the following steps.

a. Rotate the SCALE ILLUMINATION control fully counterclockwise to PWR OFF.

b. Determine the voltage available at the power output receptacle and set the 115V/230V slide switch (located on the rear panel of the Main Frame) to that position corresponding to the available source voltage.

CAUTION

The equipment is normally factory-shipped with line protective fuses rated at 1.25 amperes (delay type). If the equipment is to be powered from a 230-volt line, replace them with delay-type fuses rated at 7/10-amperes @ 230 volts and conspicuously tag the equipment that it has been modified for 230-volt operation.

c. If the equipment is to be operated from a 230-volt line, replace the existing line protective fuses with fuses rated at 7/10-ampere @ 230 volts.

WARNING

The SPA-100 and SPA-100A are designed for operation from a polarized three-terminal (one ground) power receptacle.

To eliminate the potential shock hazard to operating personnel, a three-prong to two-prong adapter should be employed to preserve the protection feature. Connect the green pigtail lead of the adapter to power receptacle ground.

d. Connect the power cord (and adapter, if required) to the power outlet.

2-12. PRELIMINARY ADJUSTMENTS. After the equipment has been coupled to line power as directed in paragraph 2-11, perform the preliminary adjustments detailed below to prepare the instrument for use.

a. Rotate the SCALE ILLUMINATION control clockwise from its PWR OFF setting; the equipment is now energized and the graticule scale will become more illuminated as the control is rotated further clockwise. Adjust the control for the desired scale illumination.

b. Allow the equipment to warm up for at least 10 minutes so that the triode local oscillator within the tuning head may stabilize. During this warmup period, set the front panel controls as listed in table 2-2.

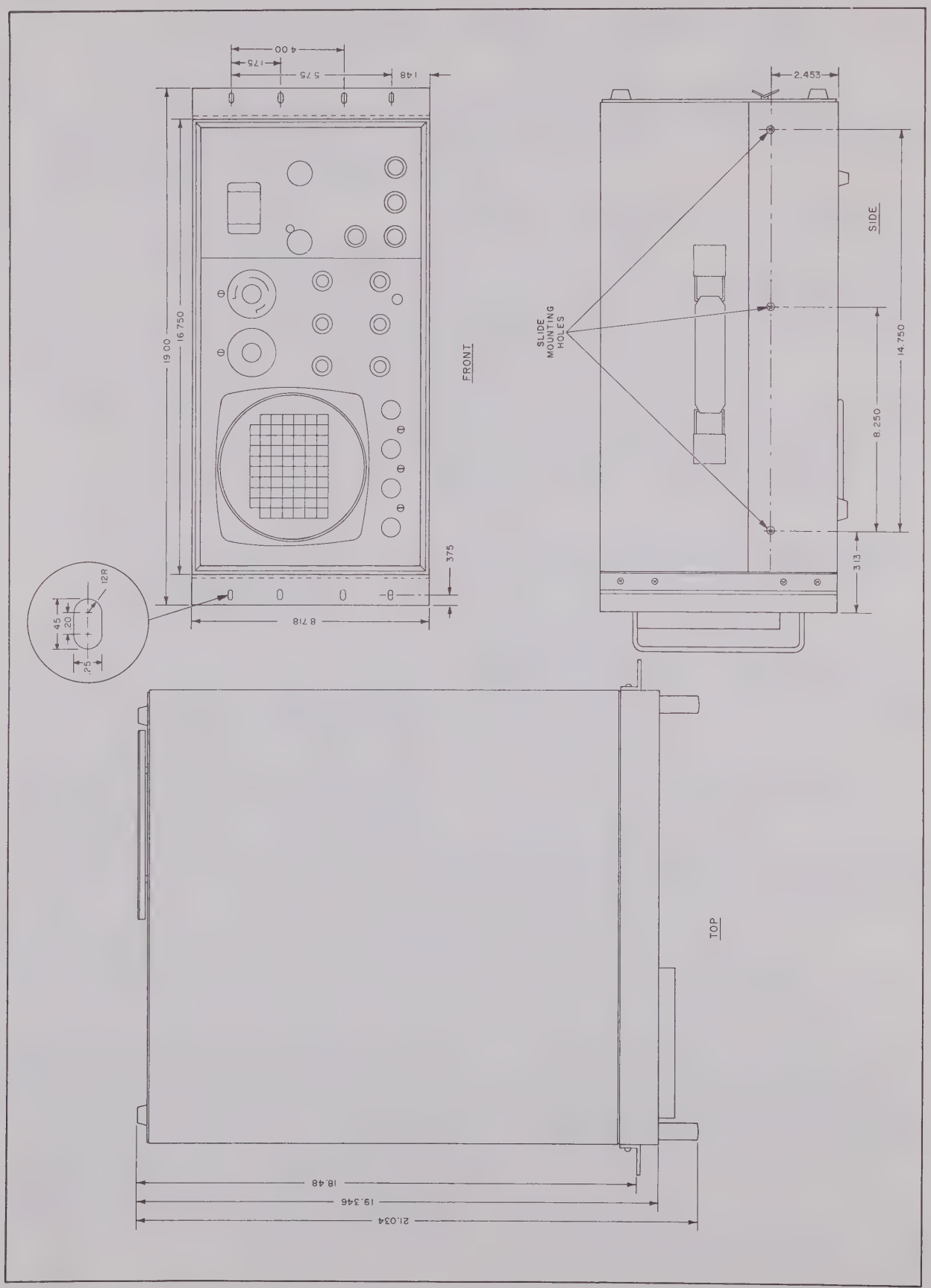


Figure 2-1. Installation Outline Drawing

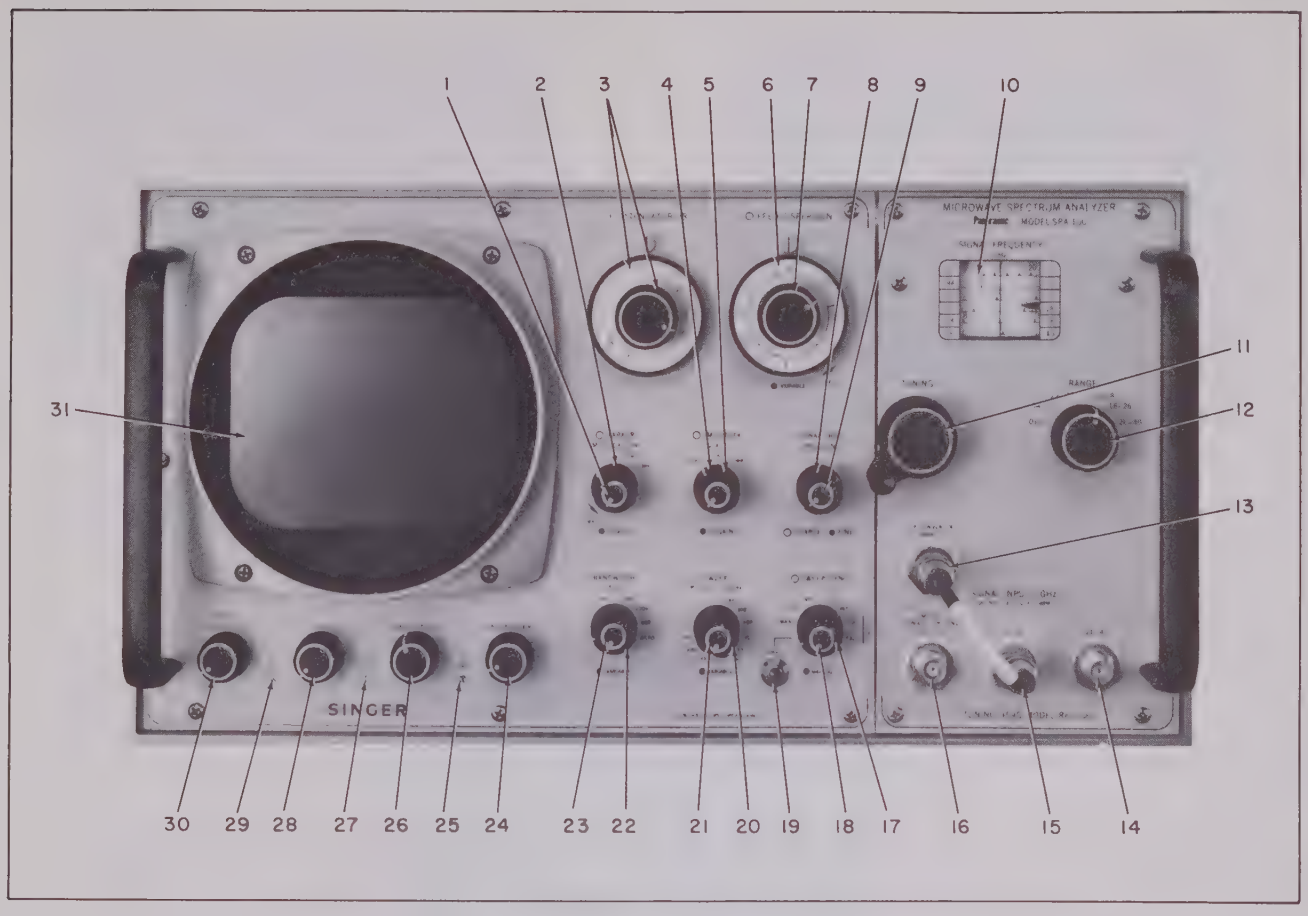


Figure 2-2. Operating Controls, Indicators and Connectors

TABLE 2-2. INITIAL CONTROL SETTINGS FOR PRELIMINARY ADJUSTMENT PROCEDURES

Control	Setting	Control	Setting
FOCUS control	Mid-range	IF GAIN control	Fully ccw
BRIGHTNESS control	Fully cw	SIGNAL FREQ POSITION f_o COURSE control	Mid-range
INTENSIFIER control	Fully ccw	SIGNAL FREQ POSITION f_o FINE control	Mid-range
IF ATTENTUATOR switches	00 dB	BANDWIDTH switch	10 kHz
FREQ DISPERSION switch	1 MHz/DIV	BANDWIDTH VARIALBE control	Fully cw
FREQ DISPERSION VARIABLE control	Fully cw (CAL)	SWEEP switch	3 MS/DIV
MARKER MODULATION switch	OFF	SWEEP VARIABLE control	Fully cw (CAL)
MARKER LEVEL control	Fully ccw (OFF)	SWEEP/SYNC switch	INT (black)
AMPLITUDE SCALE switch	LOG	MANUAL control	Any

c. Adjust the FOCUS and BRIGHTNESS controls to obtain a sharply focused and clearly visible trace.

d. Rotate the IF GAIN control fully clockwise and alternately adjust the H SIZE and H POS screwdriver controls to obtain a display that is centered on the graticule and overlaps the extreme vertical graticule lines by one-quarter division.

e. Rotate the IF GAIN control fully counterclockwise.

f. Adjust the V POS screwdriver control so that the trace coincides with the lowest horizontal graticule line.

g. Set the MARKER LEVEL control fully clockwise and adjust the SIGNAL FREQ POSITION f_o COARSE control to position the internally generated 160-MHz center frequency marker at the graticule f_o vertical line.

h. Set the FREQ DISPERSION switch to .3MHz/DIV and adjust the SIGNAL FREQ POSITION f_o FINE control to position the marker at the graticule f_o vertical line.

i. Set the FREQ DISPERSION switch to 10 MHz/DIV, the BANDWIDTH switch to 100 kHz and adjust the IF GAIN control for a noise display one division high.

j. Rotate the MARKER LEVEL control fully counterclockwise to OFF. The equipment is now ready for operation.

2-13. GENERAL OPERATING PROCEDURES.

2-14. To scan the frequency spectrum of any band, proceed as directed in the following steps.

a. After power has been applied and the equipment has been adjusted as detailed in paragraphs 2-11 and 2-12, set the SIGNAL FREQUENCY RANGE switch to the desired band to be scanned. Note that the red index on the SIGNAL FREQUENCY GHz dial indicates the selected band.

b. Rotate the SIGNAL FREQUENCY TUNING control to obtain a SIGNAL FREQUENCY dial indication corresponding to the low end of the selected band.

c. Couple the signal under analysis to the appropriate input jack.

Notes

1. If the SPA-100 is to analyze input signals within the frequency range from 10 MHz to 1 GHz, couple the signal to the SIGNAL INPUT .01-1 GHz jack and, using the supplied jumper cable, couple the SIGNAL INPUT 1-11 GHz jack to the UP CONVERTER OUTPUT jack.

2. The signal input level should not exceed -30 dBm. Signal amplitudes above this level will result in distortion and the generation of spurious signals.

3. If the input signal frequency is within the frequency range from 11 to 40 GHz, couple the signal to the appropriate external waveguide mixer (Model K_u-100, Model K-100 or Model K_a-100, as required) and couple the coaxial connector of the mixer to the SIGNAL INPUT 11-40 GHz jack.

d. Rotate the SIGNAL FREQUENCY TUNING control clockwise in search of the applied signal; the signal should enter the display from the right as the SIGNAL FREQUENCY TUNING control is rotated clockwise. If the signal enters the display from the left, it is an image signal. Once the desired signal is within the calibrated display, adjust the SIGNAL FREQUENCY TUNING control to center the presentation.

e. To determine the frequency of a spectral component, turn on the 160-MHz marker and determine the number of divisions the particular component is from the marker line (when the FREQ DISPERSION VARIABLE control is set fully clockwise at CAL). Since the marker represents the frequency which the SIGNAL FREQUENCY dial is indicating, the frequency of the particular spectral component is equal to the SIGNAL FREQUENCY dial indication plus (if the signal is to the right of the graticule f_o vertical line) or minus (if the signal is to the left) the product of the selected frequency dispersion and the horizontal displacement from the marker. For example, if the SIGNAL FREQUENCY dial indicates 10.60 GHz, the FREQ DISPERSION switch is set at 10 MHz/DIV and the spectral component is 2-1/2 divisions to the left of the marker, the frequency of the component would be 10,600 - 25 = 10,575 MHz. Another method of determining the frequency would be to energize the internal 10- or 1-MHz markers and counting the number of markers between the 160-MHz marker and signal component.

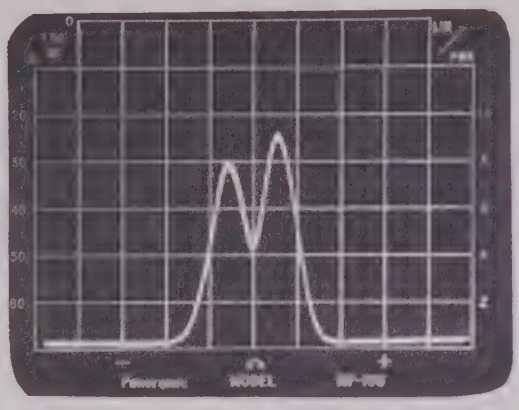
2-15. OBTAINING PROPER RESOLUTION. At wide bandwidths, input signals having a small frequency difference tend to merge into and mask each other. The ability of the analyzer to separate and identify individual signals depends upon two factors: the scanning velocity (the selected frequency dispersion in MHz/DIV or kHz/DIV divided by the selected sweep time in MS/DIV and the bandwidth of the i-f amplifier stages (see figure 2-3). For any given scanning velocity, there is a corresponding i-f bandwidth for optimum resolution: the relationship being

$$R \approx 1.5\sqrt{\frac{D}{T}}$$

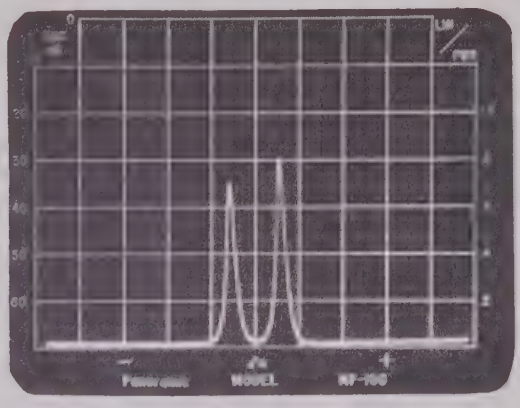
where R is the bandwidth for optimum resolution (in Hz).

D is the selected dispersion (in Hz) and

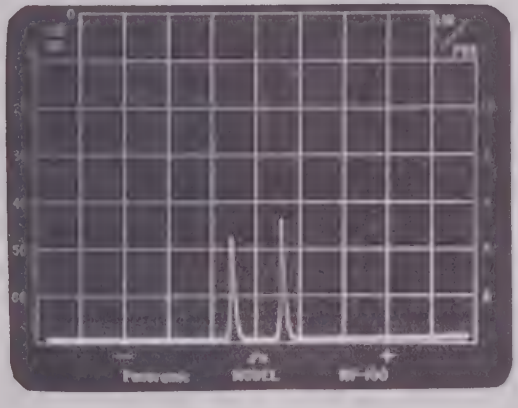
T is the selected sweep time (in seconds)



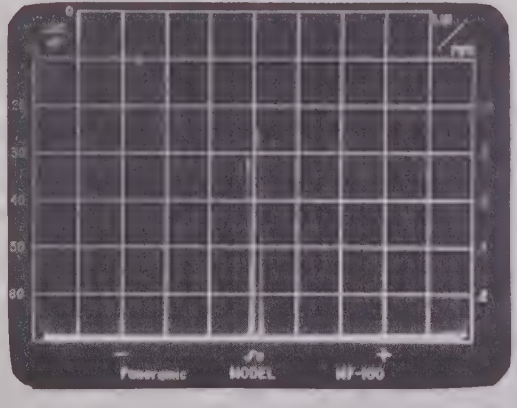
A. Bandwidth Too Broad



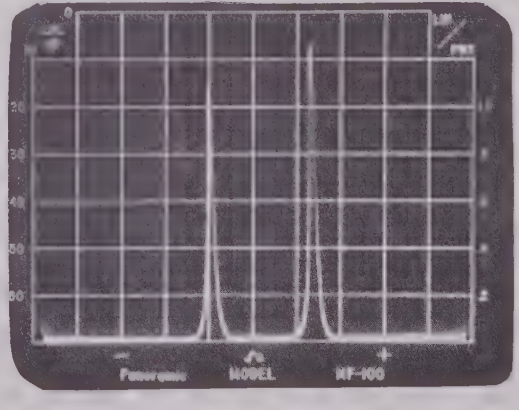
B. Optimum Bandwidth



C. Bandwidth Too Narrow



D. Two CW Signals With Excessive Frequency Dispersion



E. Same CW Signals With Proper Frequency Dispersion

Figure 2-3. Effects of Operating Controls on Display

The BANDWIDTH switch should be set to a value equal to or slightly greater than R for optimum resolution.

The scanning velocity can be reduced by decreasing the frequency dispersion scanned by each sweep or by increasing the time for one sweep. Reduction of the i-f bandwidth improves the resulution (the ability of the analyzer to separate closely-spaced signal components). If the frequency of a low amplitude signal is close to the frequency of a larger amplitude signal, the smaller pip will be masked by the skirt of the larger pip (the amplitude-versus-frequency response of the i-f circuitry being bell-shaped). As the frequency separation between the two signals increases, or the resolution of the analyzer increases, the individual signal characteristic error becomes less.

2-16. When the CRT displays a group of closely-spaced signals (such as a carrier and its sidebands) with the analyzer set for wide dispersions, the display may appear as a single pip. To examine this group of signals more closely, the operator should first center that portion of the display to be analyzed in greater detail about the graticule f_0 vertical line by adjustment of the SIGNAL FREQUENCY TUNING control and then set the FREQ DISPERSION switch for a reduced dispersion. Further improvement in display resolution may be achieved by setting the BANDWIDTH switch to VAR and adjusting the BANDWIDTH VARIABLE control until the best resolution is obtained. The BANDWIDTH VARIABLE control permits continuous adjustment of the i-f bandwidth from 1 kHz to 100 kHz. Narrowing of the i-f bandwidth (for a given scanning velocity) improves display resolution. Further reduction of the i-f bandwidth beyond the point of optimum resolution causes a severe reduction in amplitude display for CW or narrowband signals due to the limited response of the i-f amplifiers.

Note

When the BANDWIDTH switch is set to AUTO and the SWEEP switch is set to 10 MS/DIV, the proper i-f bandwidth for optimum resolution of CW or narrowband signals is automatically selected by the setting of the FREQ DISPERSION switch.

2-17. Another way to obtain better resolution is to increase the sweep time (i.e., rotate the SWEEP switch counterclockwise). The selection of the appropriate sweep time is determined by the nature of the signal being studied. For example, when the applied signal under analysis is sporadic, it is desirable to operate at short sweep times to increase the probability of intercepting the signal. When examining pulse spectra, reducing the sweep time will reduce the number of pulse lines per scan if the PRF of the applied pulse is less than the i-f bandwidth of the analyzer. However, when the PRF of the applied signal is greater than the i-f bandwidth of the analyzer, the number of lines is constant regardless of the sweep time (spectral line case).

2-18. To increase the resolution capability by reduction of the frequency dispersion, narrowing the i-f bandwidth and increasing the sweep time, the following procedure should be used.

a. Set the BANDWIDTH switch to VAR and rotate the BANDWIDTH VARIABLE control fully clockwise (i-f bandwidth = 100 kHz).

b. Adjust the SIGNAL FREQUENCY TUNING and/or SIGNAL FREQ POSITION f_0 COARSE and/or FINE controls so that the desired band of signals appears centered on the screen.

c. Rotate the FREQ DISPERSION switch counterclockwise to spread the band of signals across the screen.

d. Rotate the BANDWIDTH VARIABLE control counterclockwise until the individual signal components are clearly resolved. If proper (optimum) resolution cannot be achieved, repeat step c, set the SWEEP switch to the next slower sweep time and repeat step d.

2-19. When analyzing pulsed r-f signals it is often more desirable to view the envelope of the pulse spectrum rather than the individual spectral lines. If individual spectral lines are displayed, increase the i-f bandwidth by rotating the BANDWIDTH switch clockwise until only the envelope is displayed. To examine the envelope of noise, set the BANDWIDTH switch to 100 kHz and rotate the BANDWIDTH VARIABLE (video filter) control counterclockwise until only the noise envelope is displayed.

2-20. ZERO FREQUENCY PIP. When the SPA-100 is tuned near the low end of the 10 MHz to 1 GHz band when using dispersions in excess of 10 MHz, a zero frequency pip will appear on the display. That portion of the display to the left of zero pip is not calibrated and no information should be inferred from the appearance of the display to the left of the zero pip.

2-21. PROPER USE OF CRT SCALES. The proper use of the LOG, LIN and PWR scales is detailed in paragraphs 2-22 through 2-24, respectively.

2-22. LOG Scale. Proper use of the 60-dB LOG scale requires that the dynamic range be equal to or greater than 60 dB. The dynamic range is limited at the low end by equipment sensitivity and at the high end by over-driving of the first mixer (typically at input levels in excess of -15 dBm). To obtain the greatest upper limit capability, there must be a minimum of losses in the i-f chain: the IF ATTENUATOR switches must be set to 00 DB. The lower limit, sensitivity, is determined by the setting of the BANDWIDTH switch and the IF GAIN control. Since the sensitivity is related to the i-f bandwidth, it is recommended that the optimum bandwidth be employed (refer to paragraph 2-15) and the IF GAIN control be adjusted to obtain a noise display one division high. Note that, although a 60-dB dynamic range is achieved, spurious responses may be generated (refer to paragraphs 2-36 through 2-38).

2-23. LIN Scale. The LIN scale should be employed when it is desired to measure the amplitude difference between signals within 20 dB of each other. Note that when switching between LOG, LIN and PWR scales, the position of the trace baseline may shift vertically; the V POS screwdriver control should be adjusted to return the baseline to the lowest horizontal graticule line after scale switching has been accomplished. Should the display amplitude exceed the calibrated region of the graticule, employ the IF ATTENUATOR switches to return the display to within the calibrated area.

2-24. PWR Scale. The PWR scale is employed whenever the amplitude difference between two displayed signals is small. The PWR scale, which is square-law in nature, exaggerates small amplitude differences. As in the case with the LIN scale, the shift in baseline position should be corrected by adjustment of the V POS screwdriver control and the IF ATTENUATOR switches should be set to maintain a display within the calibrated area of the graticule.

2-25. INPUT SIGNAL CLASSIFICATION. In general, signals applied to the spectrum analyzer may be divided into two types; discrete and non-discrete. Discrete signals are in the form of periodic waveforms having frequency components which do not vary appreciably with time. The internally generated markers are typical of such signals. Although the marker output consists of harmonically related components, each frequency is discernible as a separate marker pip on the display, provided that the resolution is proper for the frequency spacing of the markers. In practice, discrete signals are typical of periodic oscillation such as modulated or unmodulated signal generators or oscillator outputs.

2-26. Non-discrete signals are typified by random noise, and the frequency distribution of energy is spread out over a broad band of the spectrum rather than consisting of line spectra. Non-discrete signals are displayed on the spectrum analyzer as a varying envelope of amplitude at each spectrum sample. The three amplitude scales (LOG, LIN and PWR) are equally valid for both random and discrete signals. It should be noted that discrete signal levels should be compared only to other discrete signal levels when relative signal strengths are to be determined and random signal levels compared to other random signal levels.

2-27. INTERPRETATION OF SCREEN PRESENTATIONS. With a little experience in the operation of a spectrum analyzer, the user will be able to readily recognize the character of the type of signal being displayed.

a. A cw signal (see figure 2-4a) appears as a deflection of fixed amplitude with the width of the presentation depending on the selected frequency dispersion, i-f bandwidth and sweep time. If the scanning velocity is not too fast, the display will be the frequency response of the i-f amplifier. Deviations from a true cw signal can be recognized as follows:

(1) Oscillator drift - display moves slowly across the screen.

(2) Periodic drift - display moves back and forth across the screen.

(3) Squegging (interruption of an oscillator at an audio or video rate) - display will resemble that of a pulse modulated signal and sideband components will be present in lobes on either side of the signal.

(4) Incidental fm - carrier pip appears to jitter on the display.

b. Two cw signals which are so close in frequency as to cause aural interference (beats) may appear as a single signal whose amplitude varies at a cyclic rate. Further separation will cause a dip at the apex of the display. By improving the resolution, the two signals will gradually separate and become readily identified. (See figure 2-4b.)

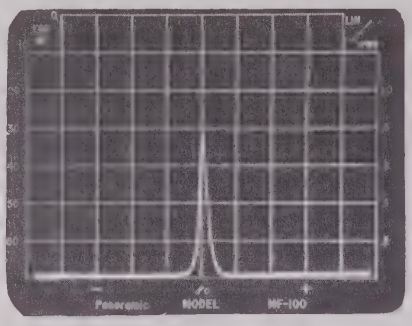
c. An amplitude-modulated carrier appears as a deflection of varying amplitude when the modulating frequency is very low. Non-constant tone modulation of low frequency will produce a series of convolutions varying in amplitude along the sides of the carrier pip. As the modulation frequency increases, convolutions move away from the deflection and sidebands become visible. (See figure 2-4c.) It becomes possible to identify the sidebands by reducing the dispersion and increasing the resolution.

d. The appearance of single-sideband signals depends on the type of modulation employed. Tone-modulated single-sideband signals appear as a carrier (for a single tone) or a series of carriers (for multi-tones) of slightly different frequency. Voice or music modulated single-sideband signals appear as a smear of rapidly varying signals which occupy a finite bandwidth. Figure 2-4d illustrates an amplitude-modulated single-sideband signal without carrier suppression.

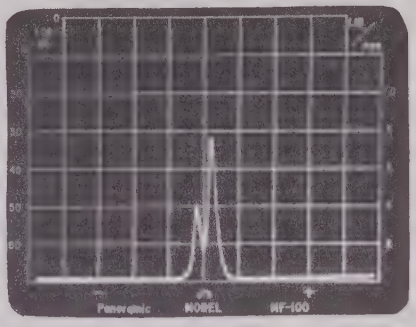
e. Frequency-modulated carriers appear as a series of vertical deflections as illustrated in figure 2-4e. The spectral lines are spaced at multiples of the modulating frequency. A carrier that is frequency-modulated at a low rate appears as a carrier that wobbles sideways. The vertical deflections shift rapidly when the carrier is modulated by voice or music, as illustrated in figure 2-4f.

f. A pulse-modulated signal (see figure 2-4g) will consist of a series of vertical spikes. The number of spikes is dependent on the pulse repetition rate, the i-f bandwidth and the sweep time. The amplitude of each spike represents the energy present at the particular frequency during one of the pulses. The peak envelope of all the spikes represents the energy distribution pattern of the signal.

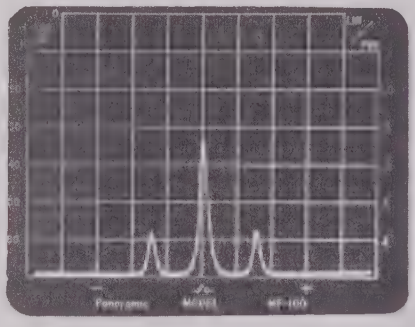
g. An impulse generator produces a train of very narrow pulses at a relatively low prf. The spectrum, which is essentially an exaggerated pulsed r-f



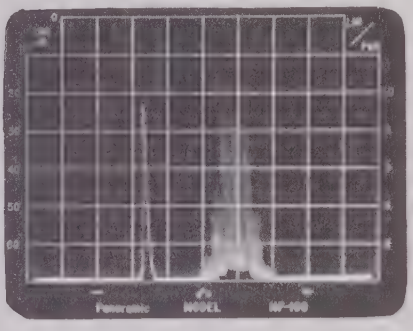
A. CW Signal



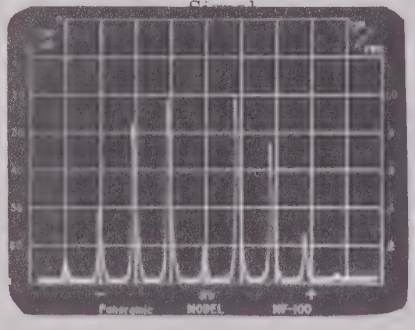
B. Two Interfering Carriers at Optimum Resolution



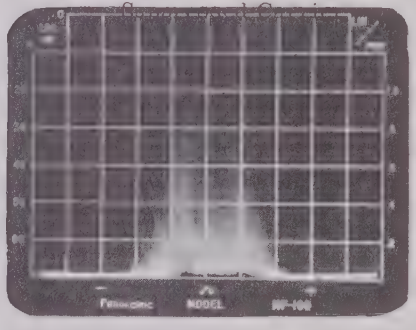
C. Single Tone Amplitude Modulated Signal



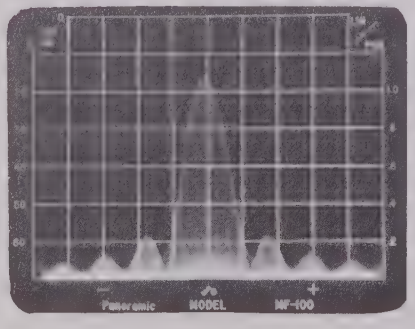
D. Single-sideband Signal Without Suppressed Carrier



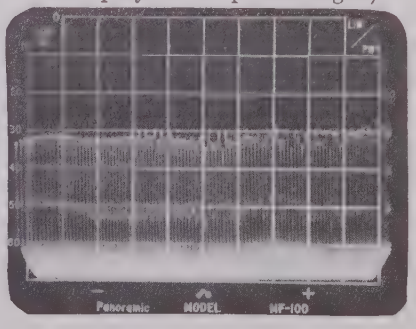
E. Frequency Modulated Signal



F. Typical Sideband Energy of Speech Modulated FM Signal (Slow Sweep Used to Display Envelope Averages)



G. Pulsed R-f Signal



H. Impulse Generator Output

Figure 2-4. Typical CRT Presentations of Discrete Signals

display, consists of an extremely broad and quite flat central lobe with very closely spaced spectral lines. (See figure 2-4h.)

h. Radio frequency interference signals of various types may appear on the screen of the spectrum analyzer. Such signals may have either broad or narrow spectral distributions, depending on the type of interference, and may occur at constant or random repetition rates. Signals which occur at a variable repetition rate (such as those produced by accelerating motors, vibrators, buzzers, etc.) may move in either direction along the frequency axis; this is caused by the fact that the spectrum analyzer is sweeping at a fixed rate whereas the observed signal occurs at a variable rate. These pips will be stationary on the screen when there is synchronization between the signal and the sweep. Signals produced by electrical arcing, switching transients, static and other short electrical impulses have broad spectra which may cover the entire frequency range of the spectrum analyzer.

2-28. CHARACTERISTICS OF PULSED R-F DISPLAYS. Since the examination of pulsed r-f signals represents an important application for spectrum analyzers, it is well to consider the characteristics of these signals and their appearance on the analyzer display. The pulse that modulates the r-f carrier contains as its frequency components the pulse repetition frequency and its harmonics. The pulsed r-f signal therefore consists of the carrier frequency and sideband components spaced at the pulse repetition frequency at either side of the carrier. Thus, the greater the pulse repetition frequency, the greater the spacing between adjacent sideband spectral lines. The width of the main lobe is equal to twice the reciprocal of the pulse width ($\frac{2}{\tau}$) while both the width of each of the side lobes and the frequency difference between the carrier and the first null point is equal to the reciprocal of the pulse width ($\frac{1}{\tau}$). Figure 2-5 illustrates typical pulsed r-f displays. Figure 2-5a shows a perfect pulsed r-f signal; the spectrum is characterized by symmetrical upper and lower sidebands and by the null points reaching the baseline. When the carrier has FM during the time of the pulse, the null points no longer reach the baseline (see figures 2-5b and 2-5c). When there is AM during the time of the pulse, the upper and lower sidebands are lower in amplitude and are spread further apart, as illustrated in figure 2-5d. Figures 2-5e and 2-5f show the effect of simultaneous amplitude and frequency modulation on the spectrum of a pulsed r-f signal.

2-29. The actual spectral lines for a repetitive pulse can be observed on an analyzer when the pulse repetition rate is greater than the resolution of the analyzer for the dispersion and sweep rate selected. When spectral lines are to be resolved, a dispersion not exceeding 100 times the prf must be employed to enable adequate visual resolution on a 5-inch CRT. Suitable i-f bandwidths and sweep rate settings less than the prf are also required for resolution of the spectral lines. For typical prf's and pulse widths, the actual spectral lines of a pulse are not resolved. In practical r-f and microwave pulsed signal analysis, the envelope of the signal is of greatest interest.

2-30. Figure 2-6 depicts the various displays obtainable of a given pulsed signal as a function of spectrum analyzer parameters. Accurate pulse spectrum plotting requires adequate selectivity for precise plotting of lobes and nulls. Excessive i-f bandwidths smear and degrade the lobe display, as illustrated in figure 2-6a. A good empirical compromise between adequate selectivity and excessive loss of pulse sensitivity due to the reduction in bandwidth is an i-f bandwidth of one-tenth the pulse width (see figure 2-6c). In use the operator sets the bandwidth as broad as possible consistent with an adequately sharp null definition for the lobes. The sweep rate is usually set at less than 1% of the prf to display at least 100 pulses per scan for adequate sectional representation. A stationary spike pattern is readily obtained through the use of external sweep synchronization. Pulse irregularities and missing pulses can be checked conveniently in this manner. Inexperienced users of spectrum analyzers often confuse the spikes due to each pulse with actual spectral lines. A simple test to determine whether spectral lines or pulse spikes are being displayed is to observe the effect that variation of the sweep rate has on the display; if the number of vertical deflections remains unchanged, true spectral lines are being displayed (see figure 2-6d).

2-31. An important factor to be considered in the analysis of narrow pulsed signals is the analyzer's usable pulse sensitivity. Spectrum analyzers are normally rated and specified for cw sensitivity at minimum i-f bandwidth. The relationship* between cw and pulse sensitivity is

$$e_{pulse} = \left(\frac{3}{2}\tau\Delta\ f_{i\text{-}f}\right)\quad e_{cw}$$

where

e_{pulse} = sensitivity to a pulsed r-f signal,

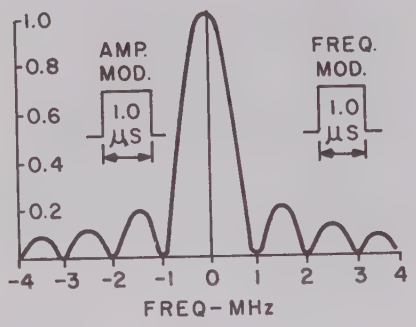
e_{cw} = sensitivity to a cw signal at the same frequency,

τ = pulse width (in seconds), and

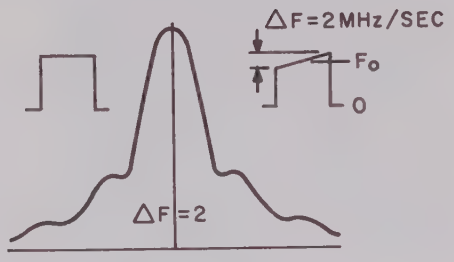
$f_{i\text{-}f}$ = analyzer 3-dB bandwidth (in Hz)

2-32. If for example, a 0.1 microsecond pulse is applied to a spectrum analyzer whose 3-dB bandwidth is 100 kHz, $e_{pulse} = 1.5 \times (0.1 \times 10^{-6}) \times (100 \times 10^{3})\ e_{cw} - 0.015\ e_{cw}$, which corresponds to a 36 dB loss in sensitivity. This loss in sensitivity is due to the fact that the i-f bandwidth required for pulse displays ($\approx \frac{0.1}{\tau}$) is much greater than the i-f bandwidth for cw displays, thereby the front end produces a much greater noise background. For a spectrum analyzer with a rated cw sensitivity at 1 kHz

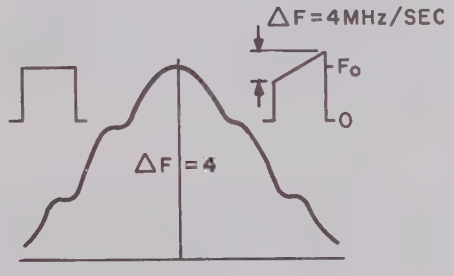
*MIT Radiation Laboratory Series, Volume XI, Chapter 7



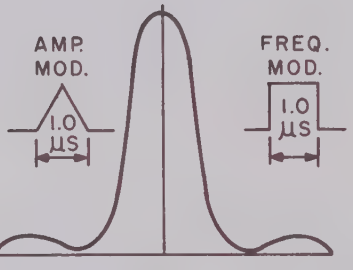
A. Spectrum of a rectangular pulse without AM or FM occurring during pulse. Shape is that of a $\frac{\sin \frac{\omega\tau}{2}}{\frac{\omega\tau}{2}}$ function.



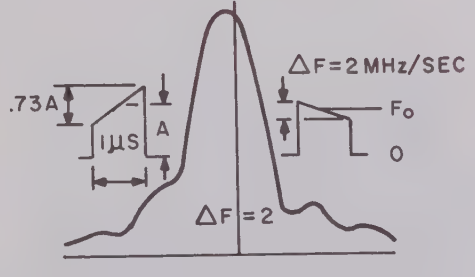
B. Spectrum of a rectangular pulse with linear FM resulting in increased sidelobe amplitude and minimums not reaching zero.



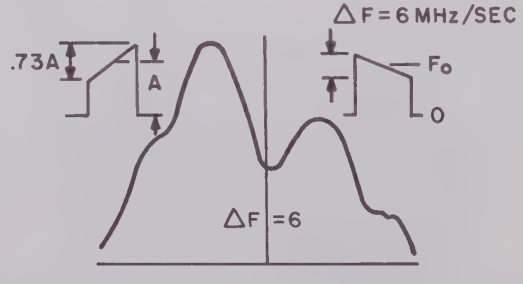
C. Same pulse as B but with more severe FM.



D. Triangular pulse spectrum without FM during pulse. Effective pulse width is shorter than A, causing minimums to occur at wider intervals of frequency and lower sideband amplitudes.

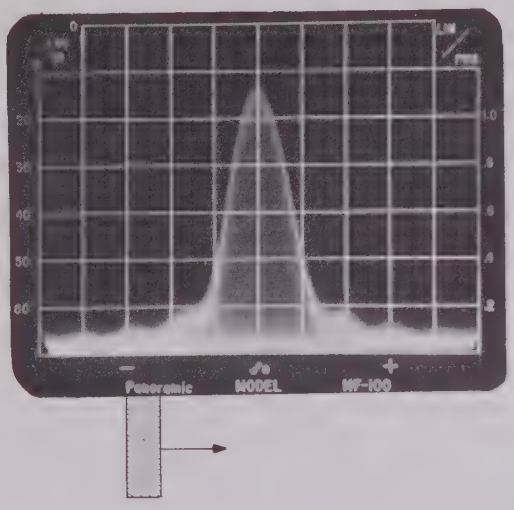


E. Effect of linear AM and FM during pulse. Observe loss in symmetry due to pulse amplitude slope.

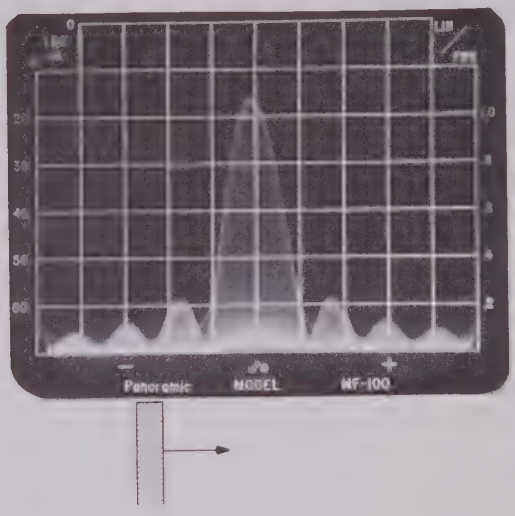


F. More severe case of FM and AM occurring during pulse.

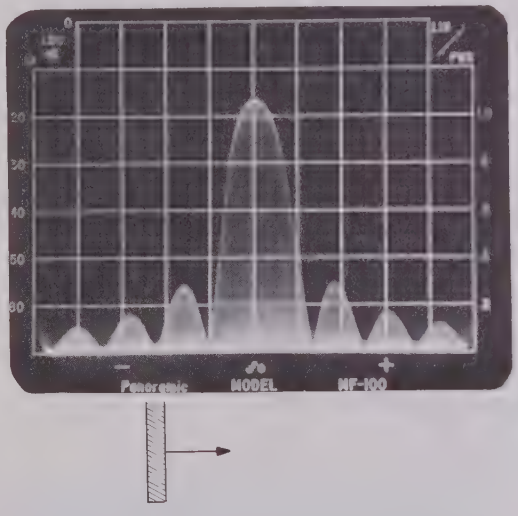
Figure 2-5. Typical Pulsed RF Displays



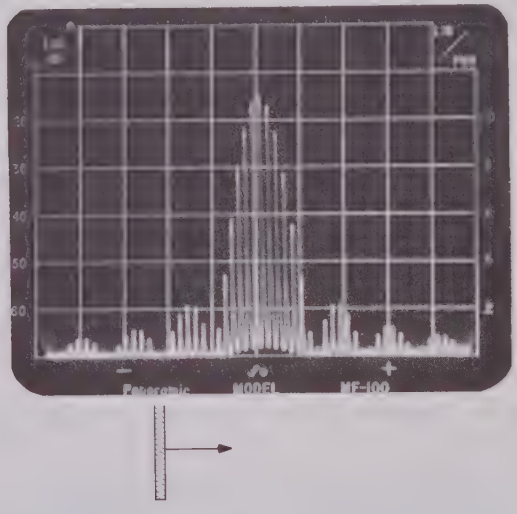
A. Extreme Case ($\Delta f_{if} \approx 1/\tau$): Extremely wide bandwidth yields minimum information.



B. Inaccurate Envelope Case ($\Delta f_{if} \approx 0.5/\tau$): Excessive i-f bandwidth fails to resolve lobe null points and distorts envelope.



C. Accurate Envelope Case ($\Delta f_{if} \approx 0.1/\tau$): Moderately narrow bandwidth does not resolve spectral lines but plots spectrum envelope accurately. Moderate prf.



D. Spectral Line Case ($\Delta f_{if} < f_{prf}$): Very narrow bandwidth resolves spectral lines (within limitations of CRT beam width and visual discrimination). High prf.

Δf_{if} = analyzer i-f bandwidth (Hz)

f_{prf} = input pulse repetition rate (pps)

τ = input pulse duration (seconds)

Figure 2-6. Effect of PRF and Analyzer Bandwidth on Pulsed Signal Analysis

bandwidth, there would be an additional 20 dB of background noise when the bandwidth is set to 100 kHz. Thus, for the example given above the total sensitivity difference between the deflection due to the 0.1 microsecond pulse @ 100 kHz i-f bandwidth and the cw signal sensitivity @ 1 kHz bandwidth would be 36 + 20 = 56 dB. At a frequency where the cw sensitivity of the spectrum analyzer is -110 dBm and the maximum signal input level for linear operation is -30 dBm, the maximum usable dynamic range for this pulse will be 24 dB[-30 dBm - (-110 dB) - 36 dB -20 dB] . For many applications where the major lobes are of prime interest, the maximum input level can be somewhat greater without significant measurement error. A practical test of adequate freedom from non-linear operation is to check the proportionality of the change in the spectrum display when a small, calibrated amplitude change is introduced. Insertion of 10-dB of attenuation into the input signal path can be used to verify that the analyzer is not being overloaded. The analyzer's sensitivity for pulsed signals can be determined by adding the loss of sensitivity (a positive value) to the cw sensitivity @ 1 kHz bandwidth (see figure 2-7).

2-33. NOISE ANALYSIS. In noise analysis (noise being defined as randomly fluctuating signals), the same general techniques are used for setting the equipment for the spectrum of interest as are used for discrete signals. If the input spectrum is broadband, it is very important to monitor the input signal level to prevent equipment overload. The following special techniques should be noted.

a. In general, a fairly wide i-f bandwidth is preferred for noise analysis. This permits relatively rapid scans since a wide i-f bandwidth gives better noise envelope averaging than does a narrow i-f bandwidth. However, if the noise source is highly selective, an i-f bandwidth which is narrow compared to the bandwidth of the resonance is required. This permits a detailed presentation of the noise characteristics. When a narrow i-f bandwidth is used, a low sweep rate is necessary for correct amplitude presentation.

b. The proper sweep rate can be determined by changing the sweep time slightly and noting whether or not there is any change in the envelope amplitude. (The portion of the envelope having the greatest slope should be examined since the greatest change will occur there.) The sweep rate should be slow enough so that a small change in the sweep rate does not result in an amplitude change. If the sweep rate is at a minimum, the frequency dispersion should be reduced and/or the i-f bandwidth increased until it is possible to make a small change in sweep rate without changing the amplitude. Once a sweep which is slow enough to obtain correct results has been established, a slower sweep can be set if improved envelope averaging is required.

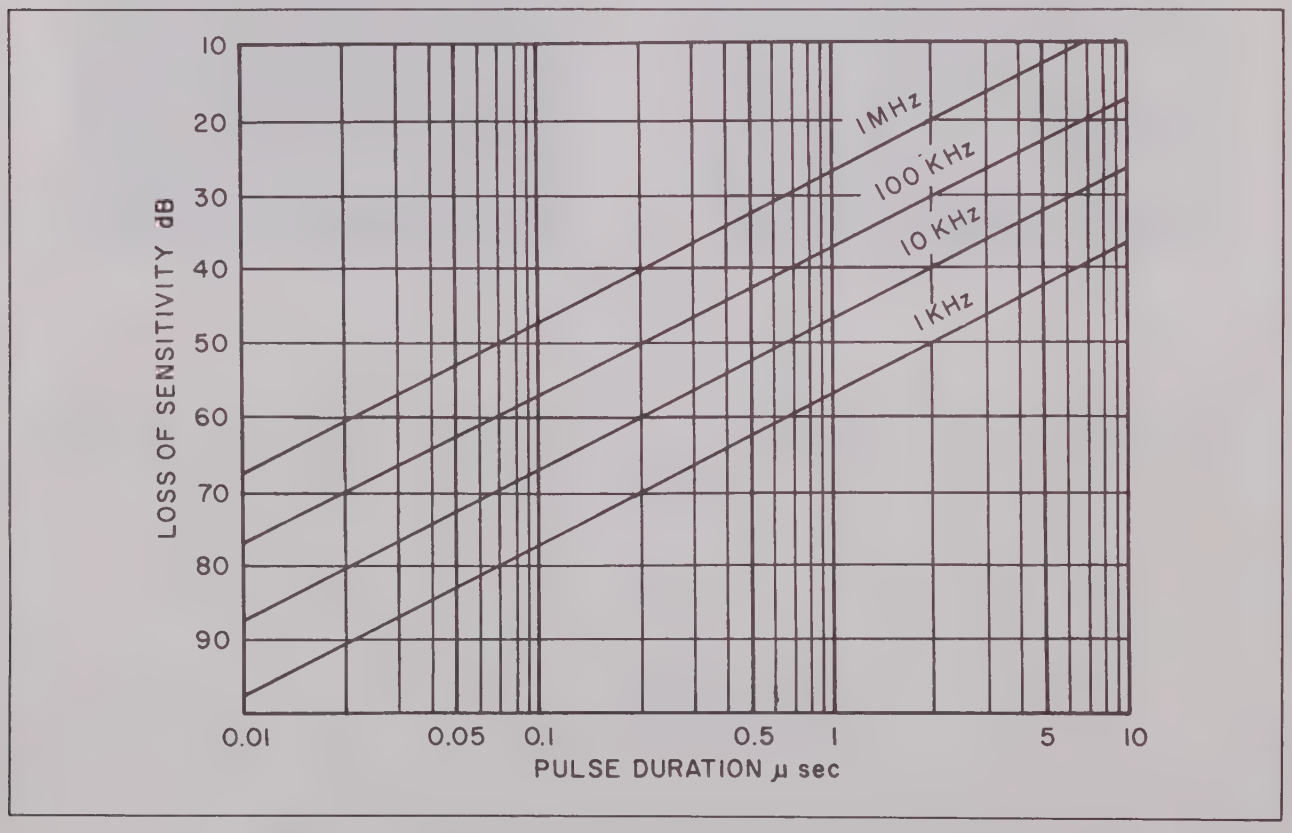


Figure 2-7. Analyzer Sensitivity Correction Due to a Pulsed Signal Compared to a CW Signal at 1 kHz Bandwidth

c. In noise analysis, video filtering can be used to obtain averaging of the noise spectrum envelope. It is usually desirable to rotate the BANDWIDTH VARIABLE control counterclockwise while the BANDWIDTH switch is in the 1, 3, 10, 30 or 100 kHz position until a single-line presentation is obtained.

d. Note that the equipment sensitivity specification in Section I is applicable only for discrete signals. If absolute noise amplitude measurements are required, the spectrum analyzer should be calibrated with a noise source of known noise output level. Such a calibration should be made at the same scanning velocity (dispersion divided by sweep time) and i-f bandwidth that is used for the signal measurement.

2-34. UNDESIRABLE RESPONSES. Because the spectrum analyzer has a broadband input section, undesirable responses may appear on the CRT screen. These responses, and how to recognize them, are described in paragraphs 2-35 through 2-41.

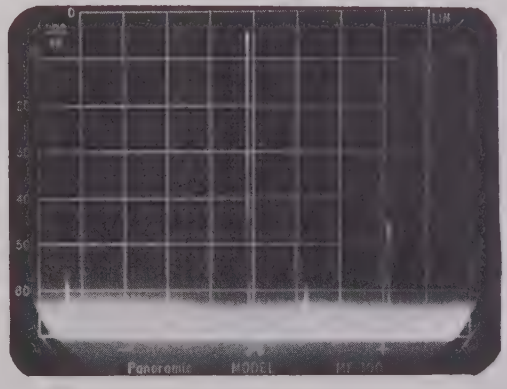
2-35. 160-MHz I-f Feedthrough Response (SPA-100 10-MHz to 1-GHz Band). This signal is easily recognized since the resultant pip will not move across the screen as the SIGNAL FREQUENCY TUNING control is adjusted, and will remain stationary like an injected marker signal. This response will be usually at least 30 dB below the proper signal response. Harmonic or image responses may be generated by this type of signal, but these will also be at lower amplitudes.

2-36. Spurious Responses. There are two sources of spurious responses generated in any spectrum analyzer; these are (1) intermodulation (IM) products, which are usually generated in the i-f section, and (2) first mixer spurious, a form of IM, which is caused by high level signals overdriving the first mixer.

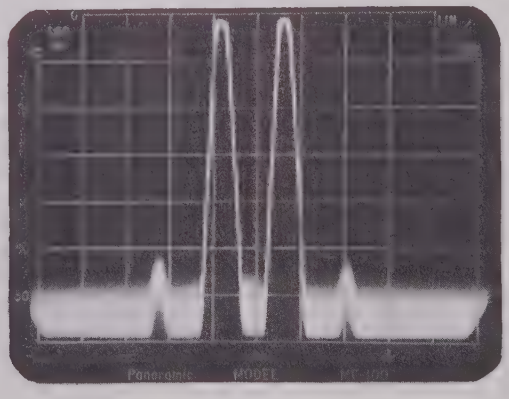
2-37. Two types of IM products may occur - single tone and two tone - both producing spurious responses that are mathematically related to the signal and/or local oscillator frequencies. Single tone IM occurs when a high level signal in the i-f mixes with the harmonic of a local oscillator (see figure 2-8a). Two tone IM occurs when two high level signals in the i-f encounter a slightly non-linear element (see figure 2-8b). In both cases the IM products are typically greater than 60 dB down when the bandwidth is 10 kHz. Reduction of the bandwidth will also improve the IM products at almost the same rate that the sensitivity is increased, provided that the input signal level is similarly reduced.

2-38. High level signal applied to the first mixer may also generate spurious responses. These are also IM products and are mathematically related to signal and/or local oscillator frequencies. Due to the broad bandwidth of the mixer, the relationship may be very obscure. In either case, spurious responses occur at input signal levels typically greater than -30 dBm. Amplitude non-linearity will not show up until signal levels are greater than -15 dBm; this level is generally specified as the point at which 1-dB compression of the signal occurs. Since the spurious responses are generated by high level signals, reduction of the input signal level and a corresponding improvement in sensitivity will result in a greater spurious-free dynamic range. Figure 2-9 permits the operator to determine the maximum linear dynamic range and maximum spurious-free dynamic range of the analyzer as a function of i-f bandwidth. Note that reduction of the i-f bandwidth and/or sweep speed improves the dynamic range.

2-39. Narrow Width, High Amplitude Pulse Response. Very narrow pulses (approximately 0.01 microseconds) of high amplitude may produce a video pulse in the first mixer ("foldover" will occur with pulses wider than 0.01 usec).

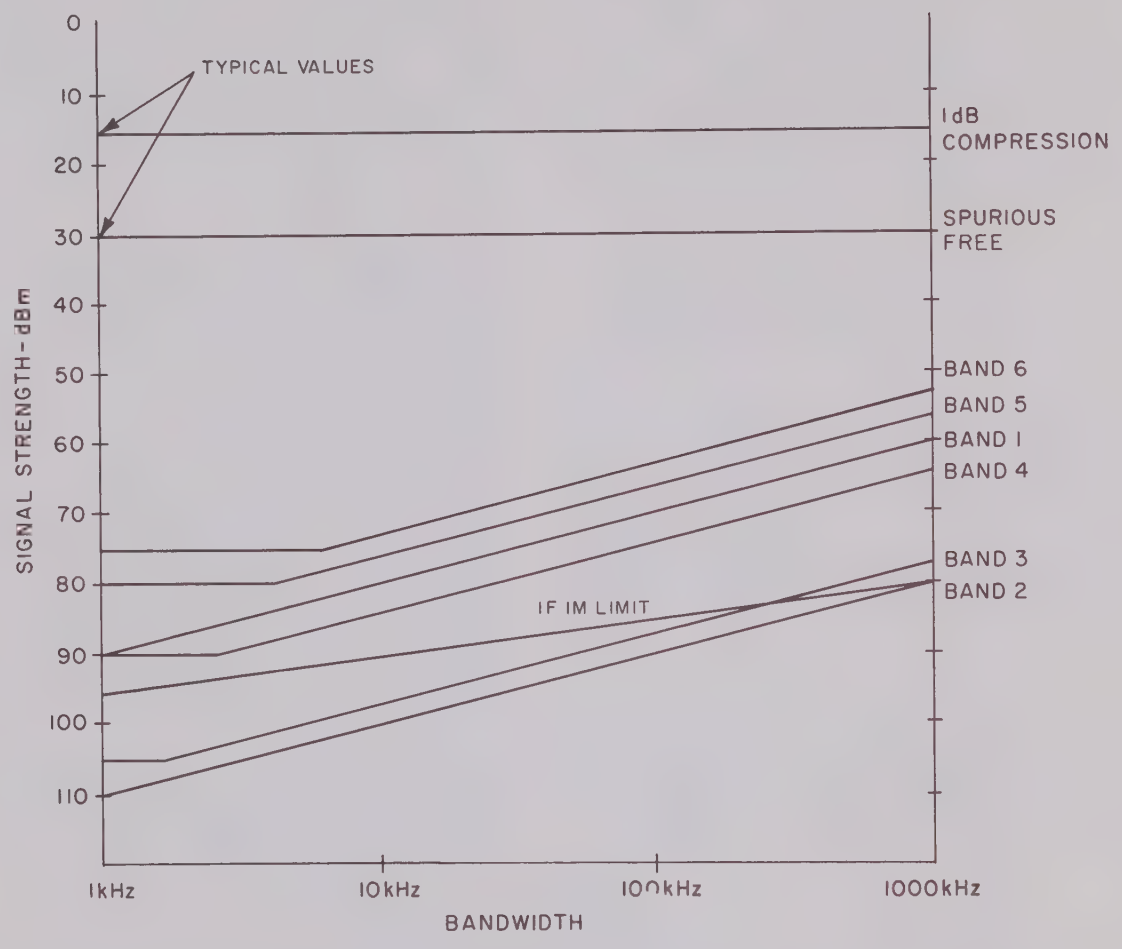


A. Single Tone IM Products



B. Two Tone IM Products

Figure 2-8. Typical Spurious Responses



Example: Determine the maximum dynamic range for both linear and spurious-free operation when the SPA-100 is tuned to 2.0 GHz and set for a bandwidth of 10 kHz.

a. Draw a vertical line through the 10 kHz point on the bandwidth axis.

b. Note the signal strength where the 10 kHz line crosses the Band 2 line (-100 dBm).

c. The maximum linear dynamic range is the difference between the 1-dB compression point (-15 dBm) and -100 dBm: 85 dB.

d. The maximum spurious-free dynamic range of the first mixer is the difference between the maximum spurious-free operating point (-30 dBm) and -100 dBm: 70 dB.

e. Note the signal strength where the 10 kHz line crosses the IF IM LIMIT line (-90 dBm).

f. The maximum spurious-free dynamic range of the i-f circuitry is the difference between the maximum spurious-free operating point (-30 dBm) and the i-f IM limit (-90 dBm) determined in step e.

g. The maximum spurious-free dynamic range is the lesser of d or f; in this case 60 dB.

Figure 2-9. Maximum Linear and Spurious-free Dynamic Ranges as a Function of Bandwidth

This video pulse (see figure 2-10) contains spectral components that will be accepted by the 160-MHz i-f amplifier. Note that most of the first sidelobe and part of the second sidelobe falls within the passband of the 160-MHz wideband i-f amplifier. These components would appear as a stationary display across the full width of the screen

2-40. Local Oscillator Image and Harmonic Response. The origin and frequency of an unidentified pip can be determined as follows:

a. Set the FREQ DISPERSION switch to 10 MHz/DIV and rotate the FREQ DISPERSION VARIABLE control fully clockwise to CAL. Note that this provides a full calibrated dispersion of 100 MHz.

b. Rotate the SIGNAL FREQUENCY TUNING control to position the display pip at the extreme right vertical graticule line. Note the frequency indicated on the SIGNAL FREQUENCY 0.94-3.5 GHz dial even though the SIGNAL FREQUENCY RANGE switch may be set to another band.

c. Rotate the SIGNAL FREQUENCY TUNING control to position the display pip at the extreme left hand vertical graticule line. Again note the frequency indicated by the SIGNAL FREQUENCY 0.94-3.5 GHz dial.

d. Calculate the difference between the SIGNAL FREQUENCY dial indications of steps b and c.

e. Calculate the order of the local oscillator harmonic which produces the signal pip by using the equation

$$n = \frac{\text{Dispersion}}{\Delta f}$$

where

n = order of local oscillator harmonic producing the pip,

Δf = difference between SIGNAL FREQUENCY 0.94-3.5 GHz dial indications (in MHz), and

dispersion = calibrated dispersion employed (e.g., 100 MHz)

Note

Round off the calculated value of n to the nearest integer. If n does not have the value of 1, 3, 5, 7 or 11, the signal is heterodyning with an improper local oscillator harmonic and the procedure of steps b through e should be repeated until the proper harmonic is obtained.

f. To check if the pip is an "image" response, compare the direction of pip travel across the screen with respect to the indication of SIGNAL FREQUENCY dial. If the signal pip moves from right to left across the screen as the SIGNAL FREQUENCY dial increases in frequency, the signal is a true signal. Conversely, if the signal moves from left to right across the screen as the SIGNAL FREQUENCY dial indicates higher frequencies, the pip is an image response. To calculate the actual frequency of the applied signal, use the appropriate equation below.

True signal: $f_x = n\, f_{dial} + (n-1)\ 160$

Image response: $f_x = n\, f_{dial} + (n+1)\ 160$

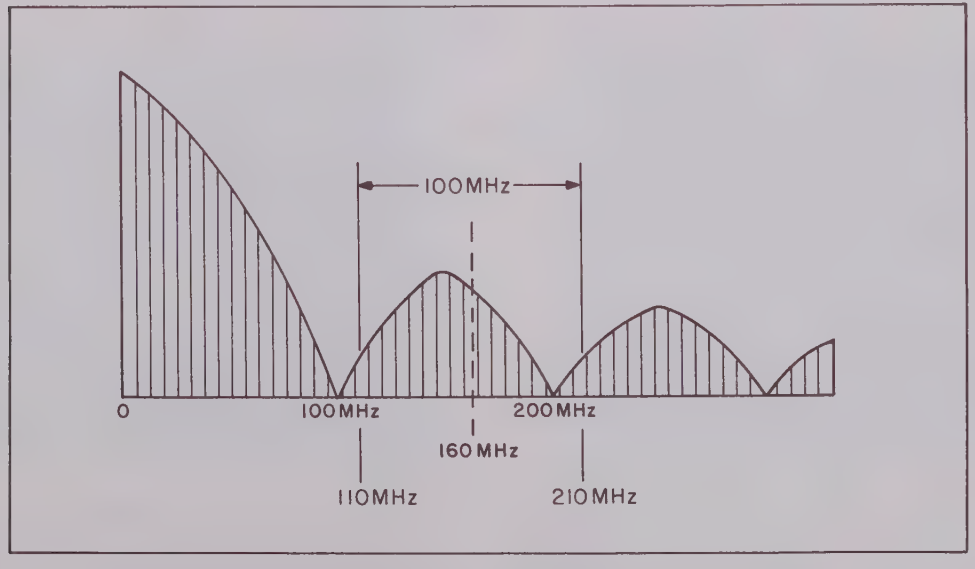


Figure 2-10. Spectrum of a 0.01 Microsecond Video Pulse

where

f_x = frequency of the unknown signal, in MHz,

f_{dial} = SIGNAL FREQUENCY 0.94-3.5 GHz dial indication (in MHz) when the signal pip is located at the center of the screen, and

n = local oscillator harmonic determined in step e.

g. Once the frequency of the unknown signal has been established, set the SIGNAL FREQUENCY RANGE to the appropriate band and adjust the SIGNAL FREQUENCY TUNING control to the frequency calculated above center the pip in the screen.

2-41. Signal Harmonic Response. If it has been determined that the pip on the screen is not caused by a harmonic response of the first local oscillator, it is possible that the pip is some harmonic of the applied signal. This possibility may be due to either a harmonic component within the signal itself or the generation of a harmonic by the overdriving of the first mixer. In either case, the fundamental signal can be found by tuning the spectrum analyzer to the various sub-harmonics (1/2, 1/3, 1/4, etc.) of the dial frequency and searching for a signal. If it is necessary to determine the source of the harmonic, either of the following procedures can be employed.

a. Insert a known amount of attenuation between the signal source and the analyzer. (The attenuator response should be flat over the band between the fundamental and harmonic frequencies.) If the harmonic amplitude response decreases by the same amount as the fundamental, the harmonic is a signal component. If, however, the harmonic response decreases at a much greater amount than does the fundamental, the harmonic is produced by overdriving the crystal mixer of the analyzer.

b. Insert a high-pass filter between the signal source and the analyzer. This eliminates the fundamental response but has a negligible effect on the harmonic if the harmonic is a part of the signal. If the harmonic component is eliminated, it was caused by overdriving the crystal mixer of the analyzer.

2-42. APPLICATIONS.

2-43. AM MEASUREMENTS. The amplitude vs. frequency display of the analyzer is useful in determining the percentage modulation of applied amplitude-modulated signals. The percentage modulation can be determined by using the LIN scale and adjusting the carrier pip amplitude for a full scale display (1 on the LIN scale). Once this has been accomplished, note the relative amplitude of one sideband with respect to the carrier. The percentage modulation is equal to twice the relative amplitude of the sideband to the carrier. Thus, if the carrier amplitude is five divisions high (1.0 on the LIN scale) and the sideband amplitude is one division high (.2 on the LIN scale), the percentage modulation is equal to 2 x 0.2/1 = 40%.

2-44. FM MEASUREMENTS. The deviation and modulation index of frequency modulated signals can be readily deduced from the relative levels of the carrier and sidebands using the Bessel function coefficients of the series expansion for an f-m signal (see Panoramic Analyzer, Volume 1, No. 4 for FM measurement techniques). Deviations of transmitters and signal generators are frequently measured by varying the modulation frequency until the first carrier null is obtained. The deviation is then obtained by multiplying this modulating frequency by 2.4. This is the most accurate practical method of measuring deviation and actual band occupancy of the sidebands. This dynamic analysis also has the advantage of the revelation of second order effects (such as residual AM) which causes assymmetry of the sidebands. To determine the deviation of an FM signal generator or transmitter, proceed as follows.

a. Couple the spectrum analyzer to the signal generator or transmitter under test. Be sure that the maximum input level to the analyzer is not exceeded.

b. With the signal generator or transmitter unmodulated, tune the spectrum analyzer to center the carrier frequency on the screen.

c. Couple a source of modulation to the signal generator or transmitter; set the modulator to a suitable frequency and minimum output level. Note that the modulation frequency should be greater than the selected analyzer bandwidth.

d. Slowly increase the modulator output amplitude until the carrier amplitude decreases to its first null. (It may be necessary to remove inserted i-f attenuation and/or increase the IF GAIN control setting to provide maximum sensitivity when observing the first carrier null.) When the first carrier null is attained, the modulation index is 2.4 and the deviation is 2.4 times the frequency of the modulating frequency. Higher order carrier nulls and/or sideband nulls can be evaluated using Bessel tables.

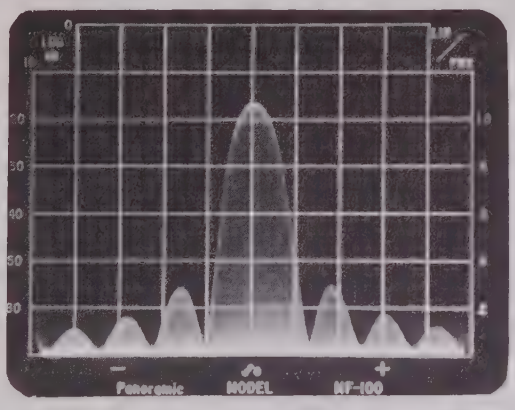
2-45. PULSE ANALYSIS. The characteristics of pulsed r-f signals can be analyzed and the pulse width measured from the amplitude versus frequency display presented during spectrum analyzer operation. Many of the pulse characteristics can be verified by converting the analyzer to a synchroscope by setting the SWEEP switch and SWEEP SYNC switch to the appropriate red settings. The pulse width, incidental am and pulse repetition rate can then be measured directly from the synchroscope display. (See figure 2-11.) To obtain a synchroscope (time domain) display of the pulsed r-f signal, first obtain a convenient spectrum analyzer display and then continue as directed below.

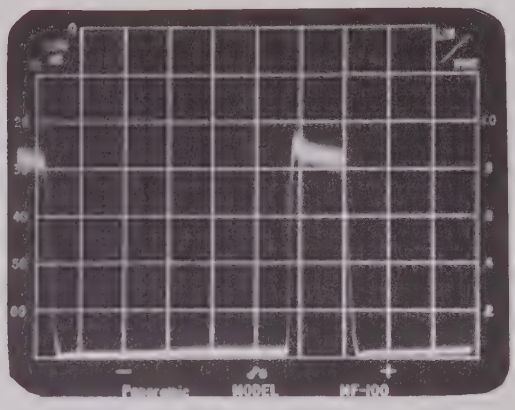
a. Set the FREQ DISPERSION switch to 0.

b. Adjust the SIGNAL FREQ POSITION f_0 COARSE and/or FINE control to obtain a maximum amplitude display on the CRT.

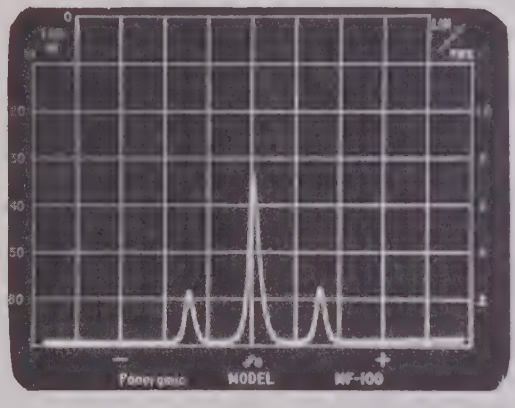
FREQUENCY BASE

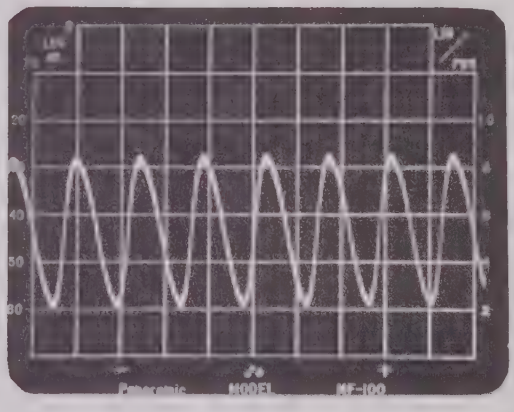
TIME BASE



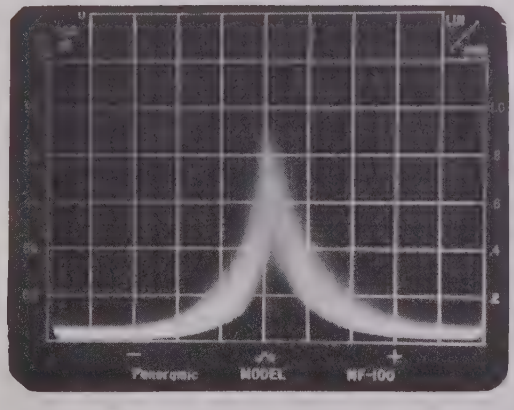


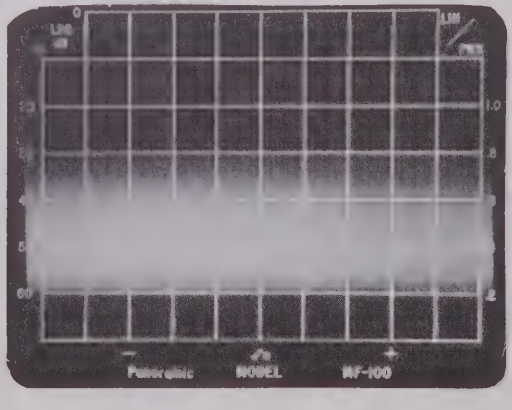
A. Pulse





B. Single Tone Amplitude Modulation





C. Noise

Figure 2-11. Comparison of Frequency-base and Time-base Displays

c. Set the SWEEP switch to any of the red USEC/DIV positions.

d. If the sweep is to be synchronized internally by the detected video signal, set the SWEEP/SYNC switch to INT SYNC (red). If the sweep is to be synchronized by an external pulse, couple the synchronizing pulse between pins D (EXT SYNC INPUT) and M (GND) of rear panel connector J1 and set the SWEEP/SYNC switch to EXT SYNC (red).

e. Set the BANDWIDTH switch to 1000 kHz.

f. Ascertain that the MARKER MODULATION switch is set to OFF and that the MARKER LEVEL control is rotated fully counterclockwise to OFF.

g. Set the AMPLITUDE SCALE switch for the desired presentation. The amplitude of the displayed pulse can be adjusted by changing the setting of the IF ATTENUATOR switches.

Note

Do not adjust the setting of the SIGNAL FREQUENCY TUNING control once in synchroscope operation. Slight retuning of the first local oscillator will cause distortion or loss of signal.

2-46. CHECKS OF RADAR SET PERFORMANCE. The spectrum analyzer can be coupled (via directional couplers or an antenna) to a radar set to evaluate its operation.

a. The radar output pulse can be observed on the spectrum analyzer to determine pulse width, pulse repetition rate, incidental AM and FM, mode failures and relative sidelobe amplitude and symmetry.

b. The energy distribution in the transmitted pulse can be determined and used as the basis for receiver bandwidth design. Should the receiver bandwidth be too narrow, the pulse shape will not be preserved and the radar accuracy will be compromised. Conversely, increasing the receiver bandwidth beyond the point of optimum energy reception serves no useful purpose and will decrease the signal-to-noise ratio.

c. Receiver afc can be checked by displaying both the magnetron output and the local oscillator frequency simultaneously. Because the magnetron is pulsed, a typical pulsed r-f pattern will represent the magnetron output. The receiver local oscillator output, however, will be represented by a single pip displaced from the center of the pulsed pattern by the i-f frequency. Any magnetron pulling resulting from antenna rotation should produce a corresponding shift in local oscillator frequency.

d. TR boxes may be tuned accurately to the magnetron frequency by first tuning the spectrum analyzer so that the magnetron frequency is centered on the display. Then, with the magnetron turned off and an impulse generator applied to the TR box, the spectrum analyzer will display the frequency response characteristics of the TR box and the TR box can then be tuned so that its center frequency is the same as the magnetron.

2-47. ANTENNA PATTERNS. An X-Y plot of antenna patterns can be obtained by using the spectrum analyzer as an r-f voltmeter and by having the analyzer sweep synchronized to the antenna rotation.

a. With the analyzer adjusted for a LOG display, couple the antenna under test to the appropriate input connector. The antenna should be installed on a rotating platform and directed toward a transmitting antenna.

b. Tune the spectrum analyzer to the transmitted frequency. Once the analyzer is tuned to the frequency of transmission, set the FREQ DISPERSION switch to 0 and carefully adjust the SIGNAL FREQUENCY TUNING control to obtain a maximum display amplitude.

c. Set the SWEEP/SYNC switch to SINGLE and set the SWEEP switch to 1000 MS/DIV.

d. Couple an external x-y recorder to the appropriate terminals of rear panel connector J1.

e. Rotate the antenna at a speed slightly faster than 6 revolutions per minute so that one complete antenna revolution will be completed within the time for one sweep.

f. When the antenna is directed away from the transmitting antenna, depress the SINGLE pushbutton switch. In this manner the main lobe of the antenna pattern will appear approximately centered on both the CRT and recorder.

2-48. RFI MEASUREMENTS. Spectrum analyzers are extremely useful when used in conjunction with RFI meters to help locate and identify the nature of the signal to be measured by the RFI meter. Except for approximate measurements, a spectrum analyzer cannot replace an RFI meter to determine absolute signal levels. On the other hand, the very narrow window of the RFI meter makes it impractical for locating signals (scanning) and the meter indications of an RFI meter are not as conclusive as a spectrum analyzer display for evaluating the type of signal being measured.

2-49. PACKAGING.

2-50. Figure 2-12 illustrates the method of packaging the analyzer for long term storage or shipment. For short term storage, use a suitable protective covering (such as a sheet of paper or plastic) and store the instrument in a clean and dry area. Store accessories and instruction manual in a carton or bag and fasten to the equipment to avoid loss.

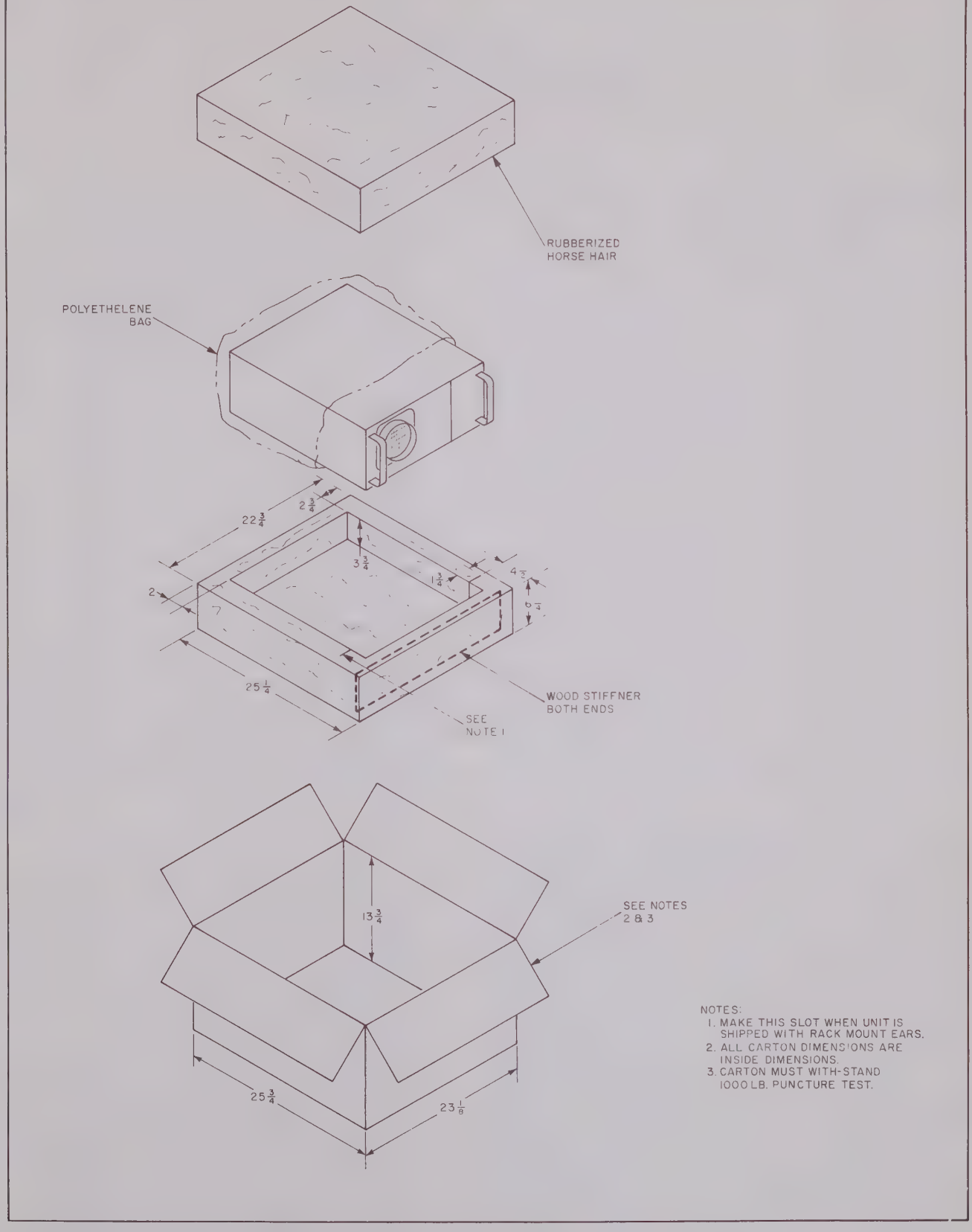


Figure 2-12. Packaging Diagram

SECTION III
THEORY OF OPERATION

3-1. GENERAL.

3-2. The RF-100 and RF-100A are multiband tunable front ends which heterodyne either the fundamental or a harmonic of a tunable internal local oscillator with an applied r-f signal to produce an intermediate-frequency output signal centered at 160 MHz. This 160-MHz i-f signal is then coupled to the MF-100 where it is further processed to provide a visual amplitude-frequency (spectrum analyzer) or amplitude-time (synchroscope) display of the applied r-f signal.

3-3. DETAILED THEORY OF OPERATION (See Figures 3-1, 5-1 and 5-3).

3-4. SIGNAL PATH, 0.94 TO 11 GHZ. When the RF-100 or RF-100A SIGNAL FREQUENCY RANGE switch is set to either .94-3.5 GHz or 3.2-11 GHz, the r-f signal under analysis is coupled through SIGNAL INPUT 1-11 GHz connector CP1 and applied to crystal diode CR1 within mixer assembly A1. R-f energy from a tunable triode local oscillator (refer to paragraph 3-9) is simultaneously applied to the diode mixer through the normally closed contacts of unenergized relay K1 and 6-dB attenuator AT1. Since the diode is a non-linear device, its output will be composed of a negative d-c level, the applied r-f signal, the local oscillator signal as well as the sum and difference products of the applied r-f signal and local oscillator fundamental frequencies and harmonics. When properly tuned, the local oscillator fundamental or harmonic is 160 MHz above the incoming r-f signal.

3-5. 160-MHZ PREAMPLIFIER A2. The composite output of the 0.94-11 GHz crystal mixer is coupled to the primary winding of transformer T1. The low-impedance transformer primary winding passes the negative d-c component of the crystal mixer output (through the low pass filter consisting of C1, L1 and FL2) to level amplifier A6 (refer to paragraph 3-10). The broadly tuned secondary of T1 passes the 160-MHz difference (i-f) frequency of the mixer while simultaneously attenuating the local oscillator component, the applied signal component, the sum frequency component as well as the sum and difference frequency products of their harmonics. That band of signals between 110 and 210 MHz is amplified by Q1 and coupled through a 2-dB pad (R4, R5 and R6) and J2 to the input of the MF-100 via the normally-closed contacts of unenergized relay K2.

3-6. SIGNAL PATH, 11 to 40 GHZ. When the RF-100 or RF-100A SIGNAL FREQUENCY RANGE switch is set to 11-18 GHz, 18-26 GHz or 26-40 GHz, the local oscillator output is coupled through the closed contacts of energized relay K1 and 6-dB pad AT3 to frequency selective "T" A4. The high-pass leg of the "T" (that which contains C1) passes the local oscillator signal through SIGNAL INPUT connector CP2 to an external waveguide mixer. The r-f signal under analysis, which is simultaneously applied to the external waveguide mixer, heterodynes with the local oscillator output. The non-linear characteristics of the mixer diode produces an output which consists of a negative d-c level, the applied r-f signal, the local oscillator signal as well as the sum and difference products of the applied r-f signal and local oscillator fundamental frequencies and harmonics. When properly tuned, the local oscillator harmonic (see table 3-1) is 160 MHz above the incoming r-f signal.

3-7. 160-MHZ PREAMPLIFIER A5. The composite output of the external mixer is returned to the frequency selective "T" and coupled to 160-MHz preamplifier A5. The negative d-c crystal current component and the 160-MHz difference frequency component are transmitted through the low-pass leg of the "T" (that leg which contains L1) to 160-MHz preamplifier A5. The negative d-c crystal current is passed through a low-pass filter (L1 and FL2) and applied to level amplifier A6. The 160-MHz difference frequency component is coupled through a broadly tuned matching network to Q1 and, after undergoing amplification, is fed through a 2-dB pad (R6, R7 and R8) and J2 to the input of the MF-100 via the closed contacts of energized relay K2.

3-8. SIGNAL PATH, 0.01 to 1 GHZ. When the RF-100 SIGNAL FREQUENCY RANGE switch is set to .01-1 GHz, the r-f signal under analysis is coupled through SIGNAL INPUT .01-1 GHz connector CP4 and applied to diode CR1 within mixer assembly A7. R-f energy from a fixed frequency 2.5-GHz oscillator chain (refer to paragraphs 3-13 through 3-15) is simultaneously applied to the mixer through 6-dB pad AT4. The d-c output of the mixer is shorted to ground by the shunt inductor in CP3 while all other signal and heterodyne products are coupled through isolator AT2, 2.5-GHz trap FL1 and bandpass filter FL2 to UP CONVERTER OUTPUT connector J1. The 2.5-GHz component of the mixer output is attenuated by 2.5 GHz trap FL1 while the applied signal component and all heterodyne products other than the desired sum frequency signal are attenuated by bandpass filter FL2. The upconverted (2.51 to 3.5 GHz) signal is then coupled between the UP CONVERTER OUTPUT connector to the SIGNAL INPUT 1-11 GHz connector where it is processed as described in paragraph 3-4. Note that isolator AT2 provides a minimum of 20 dB isolation between the tunable local oscillator output (refer to paragraph

TABLE 3-1. TRIODE LOCAL OSCILLATOR CHARACTERISTICS

SIGNAL FREQUENCY RANGE Switch Setting	Triode Local Oscillator Frequency Range	Local Oscillator Harmonic Employed	Harmonic Frequency Range
.01-1 GHz	2.67 to 3.66 GHz	Fundamental	---
.94-3.5 GHz	1.10 to 3.66 GHz	Fundamental	---
3.2-11 GHz	1.12 to 3.72 GHz	3rd	3.36 to 11.16 GHz
11-18 GHz	2.23 to 3.63 GHz	5th	11.16 to 18.16 GHz
18-26 GHz	2.59 to 3.74 GHz	7th	18.16 to 26.16 GHz
26-40 GHz	2.37 to 3.65 GHz	11th	26.16 to 40.16 GHz

3-9) and mixer diode A7CR1, thereby minimizing the generation of spurious responses and IF feedthru when the RF-100 is operating in this band.

3-9. TRIODE LOCAL OSCILLATOR A3. Local oscillator power for heterodyning with the applied r-f signal is obtained from ceramic triode V1 operating in an integral tunable dual cavity. The triode and cavities combine to form a tuned-plate tuned-cathode oscillator and the frequency of oscillation is determined by the physical length of the plate and cathode cavities. The physical length of both cavities is determined by the setting of the SIGNAL FREQUENCY TUNING control. Output power is extracted from the plate cavity by probe coupling. The frequency range, harmonic employed and harmonic frequency range of the tunable local oscillator as a function of the selected tuning band are listed in table 3-1.

3-10. LEVEL AMPLIFIER A6. Conventional tunable local oscillators have output level variations that are a function of operating frequency. These variations cause the first mixer d-c output current to fluctuate as a function of frequency and consequently does not permit the diode to be operating at its optimum point. The circuitry of level amplifier A6 keeps the crystal current output of the mixer constant across the band, thereby obtaining optimum sensitivity and flatness of response throughout the band.

3-11. Assume that the SIGNAL FREQUENCY RANGE switch is set to .94-3.5 GHz and that the SIGNAL FREQUENCY TUNING control is adjusted to obtain a SIGNAL FREQUENCY dial indication at the low end of the band (.94 GHz). The d-c crystal current component of mixer A1CR1 is coupled through closed contacts W2 and 8 of S1B and closed contacts W1 and 2 of S1C across R9 to establish base to ground voltage at difference amplifier A6Q3. The base bias of A6Q2 is adjusted by Band 2 screwdriver control R4 so that collector current of A6Q1 sets the plate-to-cathode voltage of A3V1 (hence the oscillator output level) at that value which will provide an optimum crystal current of 1 milliampere. Should the output level of the oscillator change as it is tuned to another frequency, the change in crystal current will be sensed by difference amplifier A6Q3/A6Q2, causing the collector current of A6Q1 to change in that direction which causes the local oscillator output level to shift and return the crystal current to the optimum level of 1 ma.

3-12. 2.5-GHZ FIXED LOCAL OSCILLATOR. The 2.5-GHz signal required to supply local oscillator power for the up-converter in the RF-100 is obtained from a 104.167-MHz oscillator and frequency tripler (refer to paragraph 3-14) whose output is then multiplied up to 25 GHz (refer to paragraph 3-15).

3-13. 104.167-MHz Oscillator-Frequency Tripler A9. When the SPA-100 is operating in the .01-1 GHz band, +12 and -12 volts are supplied to 104.167-MHz oscillator-frequency tripler A9 (see figure 5-2). Grounded-base amplifier A1Q1, in conjunction with the positive feedback path through crystal A1Y1, provides a 104.167-MHz output which is coupled through buffer amplifier A1Q2 to frequency tripler A2Q1. The frequency tripler, which is biased to operate in its non-linear region, produces an output that is rich in harmonics. The fundamental and second harmonic components of the tripler output are shunted to ground by means of the resonant circuits consisting of A2L4 and A2C7 and A2L5 and A2C8. The series resonant circuit of A2L6 and A2C9 passes the 312.501-MHz third-harmonic component while simultaneously attenuating all higher-order harmonics. The 312.501-MHz signal is coupled through a 3-dB pad (A2R3, A2R4 and A2R5) to buffer amplifier and frequency multiplier A8.

3-14. Buffer Amplifier and Frequency Multiplier A8. The 312.501-MHz output of A9 is coupled to buffer amplifier Q1 of A8. The buffer amplifier, which is a grounded-base amplifier, drives a step recovery diode frequency multiplier. The frequency multiplier consists of harmonic generator CR1 operating in a tunable coaxial cavity. The cavity, which is tuned to 2.5 GHz, passes the eighth harmonic (while attenuating all other responses) through coupler CP5 to bandpass filter FL3. FL3 is tuned to 2.5 GHz and therefore passes only the desired

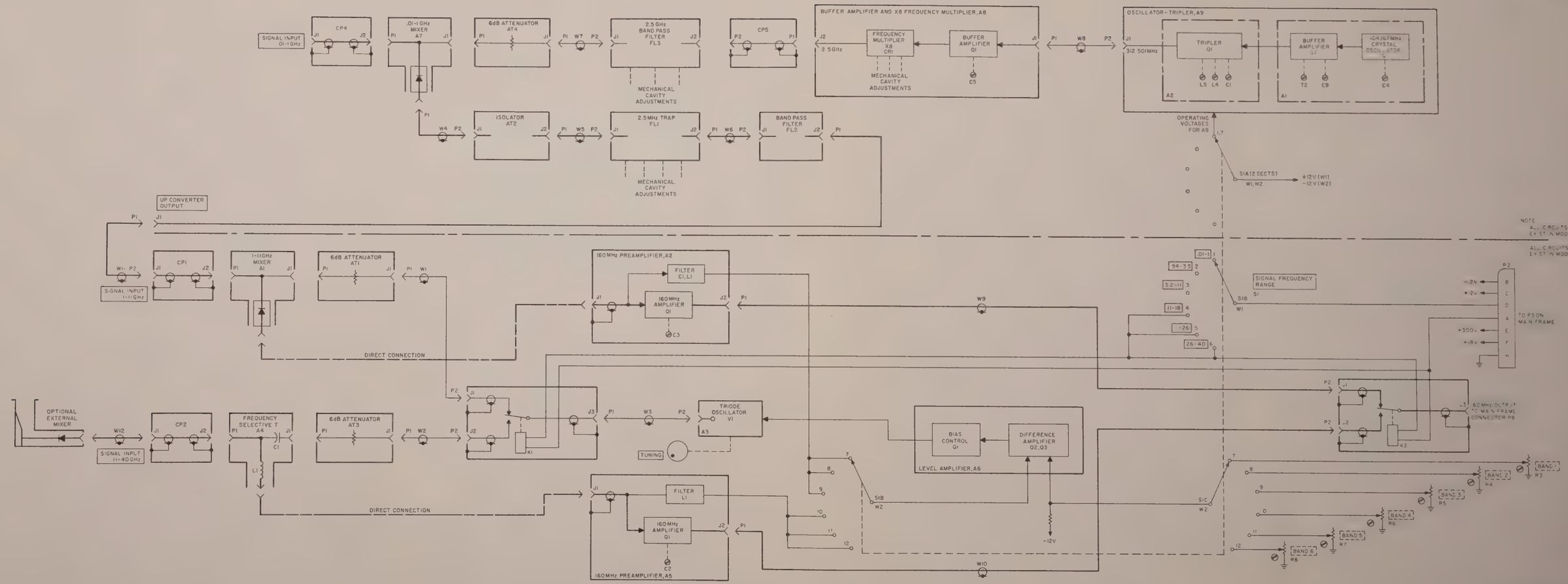


Figure 3-1. RF-100 and RF-100A, Detailed Block Diagram

eighth harmonic of the harmonic generator further suppressing the other harmonics to upconverting mixer A7CR1.

3-15. POWER DISTRIBUTION. All power required for the operation of the RF-100 and RF-100A is derived from the MF-100 through multipin connector P2 on the tuning head.

SECTION IV
MAINTENANCE

4-1. GENERAL.

4-2. This section contains maintenance, alignment and calibration instructions for the RF-100 and RF-100A. Included are a list of test equipment, minimum performance standard checks to determine whether the equipment operates within the limits of published specifications, systematic troubleshooting procedures localizing malfunctions to an individual subassembly or circuit, and alignment and calibration procedures necessary to restore the equipment to proper operating condition after the required repairs have been effected.

4-3. TEST EQUIPMENT REQUIRED.

4-4. The test equipment required for the maintenance, alignment and calibration of the equipment is listed in table 4-1. Equipment with similar characteristics may be substituted for any item listed in the table.

TABLE 4-1. REQUIRED TEST EQUIPMENT

Manufacturer	Nomenclature
Hewlett-Packard	Models 608D, 612, 614A, 616B, 618C, 620B, 626A and 628 Signal Generators
Hewlett-Packard	Models 938A and 940A Frequency Doublers
Hewlett-Packard	Model 536A Wavemeter
Hewlett-Packard	Model 423A Detector
Simpson	Model 260 Multimeter
Hewlett-Packard	Model 8406A Comb Generator
Hewlett-Packard	Model HP130C Oscilloscope
Singer Metrics	Model AT-100 R-f Attenuator Set
Hewlett-Packard	Model 430C Power Meter
Hewlett-Packard	Model 477B Thermister Mount
Singer Metrics	Model SPA-100 Spectrum Analyzer
Microlab	Model HC-10N Sampler
Hewlett-Packard	Model 692D Sweep Generator
Hewlett-Packard	Model 536A Frequency Meter
Hewlett-Packard	Model 423A Negative Polarity Crystal Detector
Weinschel	Model 953 Variable Attenuator
Airborne Instrument Lab	Type 391 Microwave Crystal Test Set

4-5. MINIMUM PERFORMANCE STANDARDS.

4-6. The minimum performance standards checks of table 4-2, when performed, determine whether the equipment is functioning within the specifications listed in Section I. If the equipment fails to provide the "acceptable indication" specified, the operator should refer to the applicable troubleshooting, replacement, repair, alignment and calibration procedures to correct the defect. Energize the equipment as described in paragraph 2-11. The test setup for these checks is illustrated in figure 4-1.

TABLE 4-2. MINIMUM PERFORMANCE STANDARDS CHECKS

Step	Purpose	Procedure	Acceptable Indication
1	To set up the unit for testing	Set the following controls as indicated: SCALE ILLUMINATION — cw FOCUS — mid BRIGHTNESS — cw INTENSIFIER — ccw IF ATTENUATOR — 00dB FREQ DISPERSION 1. Step — .3 MHz/DIV 2. VAR — CAL MARKER 1. MODULATION — OFF 2. LEVEL — CW AMPLITUDE SCALE — LIN IF GAIN — mid SIGNAL FREQ POSITION 1. COARSE — mid 2. FINE — mid BANDWIDTH 1. Step — 100 kHz 2. VAR — CW SWEEP 1. Step — 3MS/DIV 2. VAR — CAL SWEEP/SYNC — INT SWEEP **Note** Models RF-100 and RF-100A require a warm up of 10 minutes before attempting to adjust any controls. Adjust the FOCUS and BRIGHTNESS controls. Adjust the H POS control. Adjust the V POS control.	A clearly-visible sharply focused trace. Center the trace. Offset the trace approximately 2 divisions from the base line.

(Cont'd)

TABLE 4-2. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

<table>
<tr><th>Step</th><th>Purpose</th><th>Procedure</th><th>Acceptable Indication</th></tr>
<tr><td></td><td></td><td>Adjust the H SIZE control.

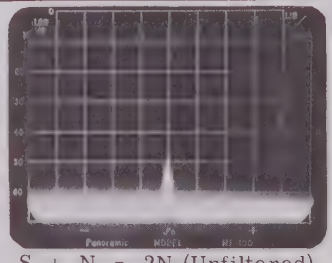
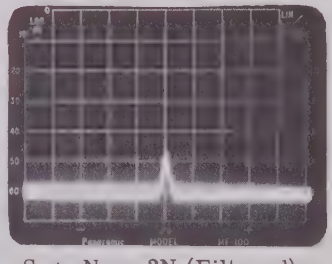
Readjust V POS control.

Adjust SIGNAL FREQ POSITION control.</td><td>The trace should extend 1/4 division beyond each side of the calibrated screen.

Set the trace coincident with the baseline.

Center the pip on the screen.</td></tr>
<tr><td>2</td><td>To check the frequency accuracy of the unit.</td><td>Using the test set up of figure 4-1 with no signal generator input, set the RANGE switch to 11-40 GHz, and using the .94 to 3.5 GHz scale of the tuning head, measure the frequency of the local oscillator at the 11-40 GHz SIGNAL INPUT jack of the unit under test, at different points on the band.</td><td>The observed local oscillator should be 160 MHz above the indicated signal frequency on the tuning dial, ± 1%.</td></tr>
<tr><td>3</td><td>To check the sensitivity of the unit.</td><td>Connect a signal generator, through a 10 dB attenuator (see figure 4-1) to the appropriate SIGNAL INPUT jack for the applied frequency. Using the Main Frame internal markers, obtain a display centered on the CRT screen with the trace positioned on the lowest graticule line. Set the SIGNAL FREQUENCY RANGE switch to the desired band. Adjust the SIGNAL FREQUENCY TUNING control to obtain the test frequency indication on the SIGNAL FREQUENCY dial; fine tune to position the signal in the center of the CRT display. Adjust the IF GAIN control to obtain a display of noise whose peaks average .2 on the LIN scale of the graticule. Reduce the signal generator output level to obtain a pip peak coincident with the LIN scale 0.4 line. That is, signal (S) plus noise (N) equals twice noise (2N). To reduce errors caused by operator interpretation of the noise display, adjust the BANDWIDTH VARIABLE control fully ccw to obtain an easily discernable S+N = 2N display. Note the signal generator output level in dBm, the sensitivity is equal to the signal generator output level less the 10 dB loss of the pad and a correction factor as follows:

<table>
<tr><th>Band</th><th>Procedure Freq Range</th><th>Correction Factor</th></tr>
<tr><td>1</td><td>.01 to 1 GHz</td><td>20 dB</td></tr>
<tr><td>2</td><td>.94 to 3.5 GHz</td><td>20 dB</td></tr>
<tr><td>3</td><td>3.2 to 11 GHz</td><td>18 dB</td></tr>
<tr><td>4</td><td>11 to 18 GHz</td><td>16 dB</td></tr>
<tr><td>5</td><td>18 to 26 GHz</td><td>14 dB</td></tr>
<tr><td>6</td><td>26 to 40 GHz</td><td>12 dB</td></tr>
</table>
(See NOTE following this table)

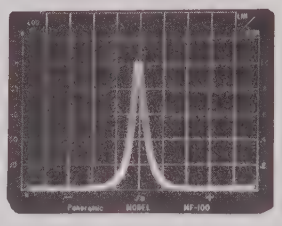
Check the sensitivity of the set at 0.1 GHz intervals for band 1; 0.25 GHz intervals for band 2; 0.5 GHz intervals for band 3; 1.0 GHz intervals for band 4 and 5; and 2.0 GHz for band 6.</td><td> 
S + N = 2N (Unfiltered)
 
S + N = 2N (Filtered)

Example: If the set is tuned to 8.0 GHz and the signal generator output level is -79 dBm, the actual sensitivity of the set at 1 kHz bandwidth is -79 dBm - (10 dB + 18 dB) = -107 dBm.

<table>
<tr><th>Sensitivity</th></tr>
<tr><td>-90 dBm</td></tr>
<tr><td>-110 dBm</td></tr>
<tr><td>-105 dBm</td></tr>
<tr><td>-90 dBm</td></tr>
<tr><td>-80 dBm</td></tr>
<tr><td>-75 dBm</td></tr>
</table></td></tr>
</table>

(Cont'd)

TABLE 4-2. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
4	To check the incidental FM of band 2.	Connect the comb generator to the 1-11 GHz SIGNAL INPUT and set for a 100 MHz output. Adjust the SIGNAL FREQUENCY TUNING control to center the signal indication of the display. Set the SWEEP control to 1000 us/ DIV (red). Set the BANDWIDTH switch to 1 kHz. Reduce the FREQ DISPERSION to 1 kHz/DIV. Measure and record the horizontal jitter of the displayed signal.	1 division or less 

Note

Using the 100 kHz bandwidth instead of the 1 kHz bandwidth in the actual sensitivity measurement removes the inaccuracy caused by the frequency instability of signal generators. Most microwave signal generators have incidental FM's of up to 50 kHz, while the spectrum analyzer has resolving capabilities of 1 kHz. However when the measurement is taken at 100 kHz a correction factor is required. The correction factor is made up of two components: the first is due to the measurement of sensitivities with a 100 kHz bandwidth while the sensitivity specification is with a 1 kHz bandwidth; the second is the minimum resolution limitation due to the incidental FM of the local oscillator.

If a sensitivity measurement is obtained using a bandwidth of 100 kHz, it can be translated, simply, to an equivalent sensitivity measurement taken with a bandwidth of 1 kHz, using the equation:

$$\text{correction factor} = 10 \log \frac{\Delta f \text{ 100 kHz}}{\Delta f \text{ 1 kHz}}$$

This discussion assumes that the spectrum analyzer can resolve 1 kHz, but it can do this only over a portion of the band. The factor that limits the resolving capability of the spectrum analyzer is the incidental FM of the first local oscillator. Any selected bandwidth narrower than the resolving capability of the spectrum analyzer is not useful. Therefore, the correction factor is limited to minimum useful bandwidths equal to the incidental FM of the operating harmonics of the triode local oscillator. The typical indicental FM of the fundamental of the triode local oscillator is 500 Hz. Therefore, for operation on the third and higher harmonics, the spectrum analyzer cannot usefully resolve 1 kHz, and the correction factor for this bandwidth is less than the 20 dB figure obtained from the equation. The proper correction factor associated with any bandwidth useful at a given frequency range, is obtained by substituting the limiting factor of minimum useful resolution, in kHz, for the 1 kHz term in the above expression.

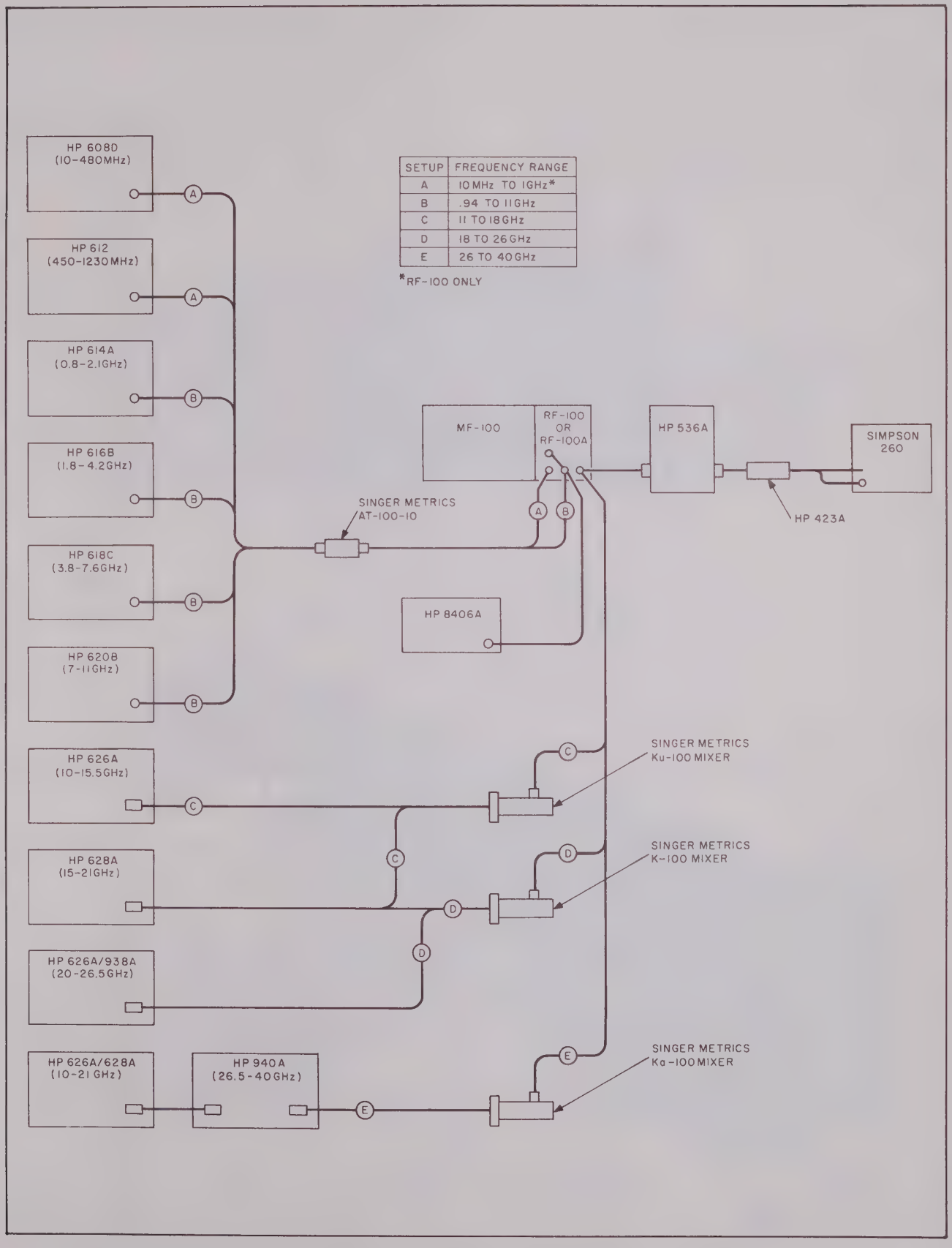


Figure 4-1. Equipment Setup for Minimum Performance Checks

4-7. PRELIMINARY INSPECTION.

4-8. Preliminary inspection of the equipment is performed without operating power applied. The inspection is designed to detect any conditions that if left alone might cause a breakdown. Frequent causes of premature failure are: overheating due to improper ventilation, accumulations of dust and dirt, and/or loose connections and fittings. Inspection is carried out with emphasis placed upon finding evidence of these conditions.

4-9. COMPONENT LOCATIONS.

4-10. The major components of the equipment, as well as all of the components mentioned in the alignment and troubleshooting procedures supplied in this section, are illustrated in figures 4-2 through 4-7.

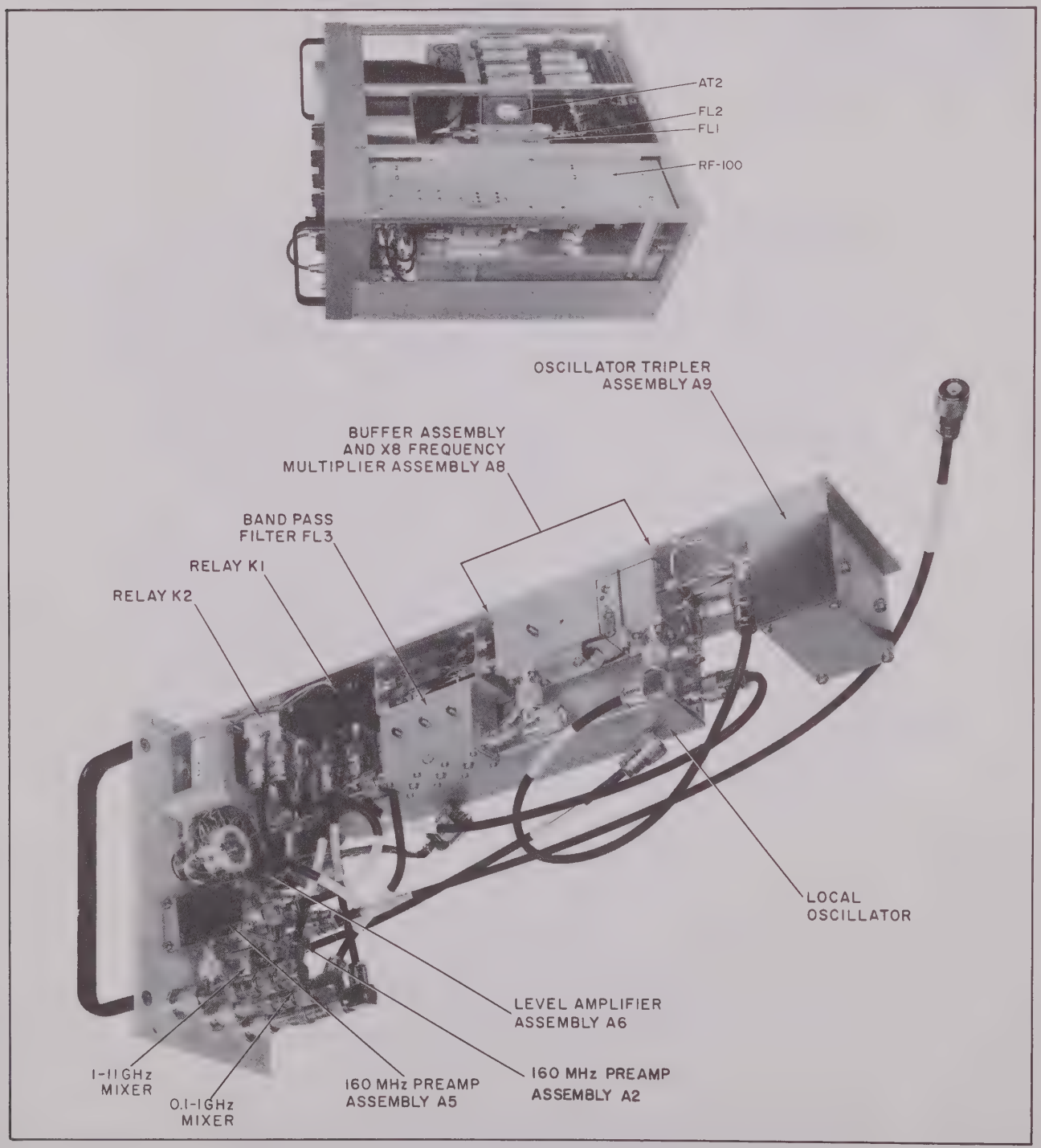


Figure 4-2. Major Assemblies of RF-100

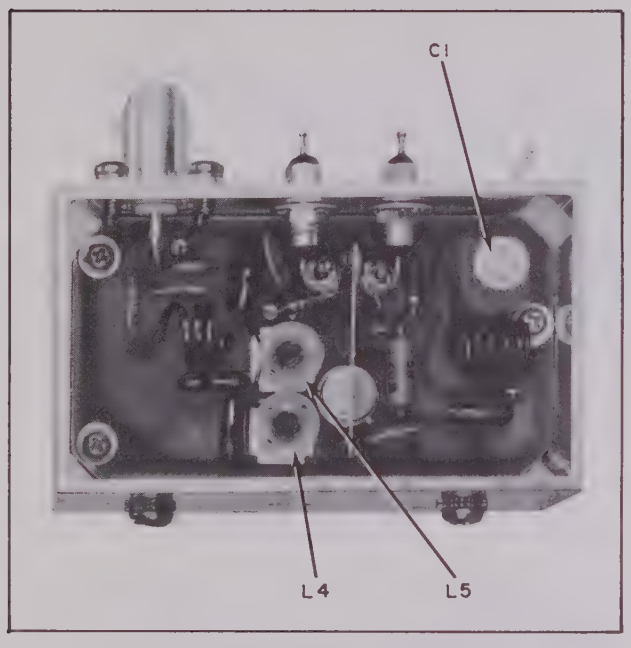


Figure 4-3. Oscillator-Tripler A9 (Tripler Section)

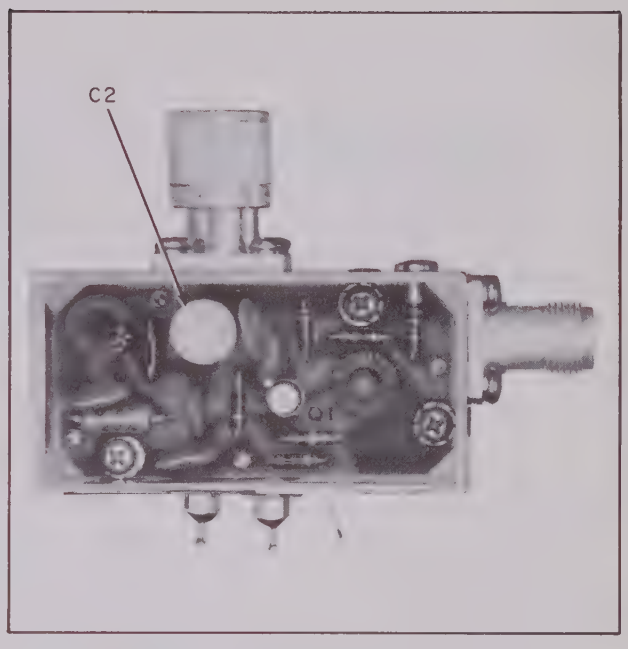


Figure 4-4. 160-MHz Preamplifier A2

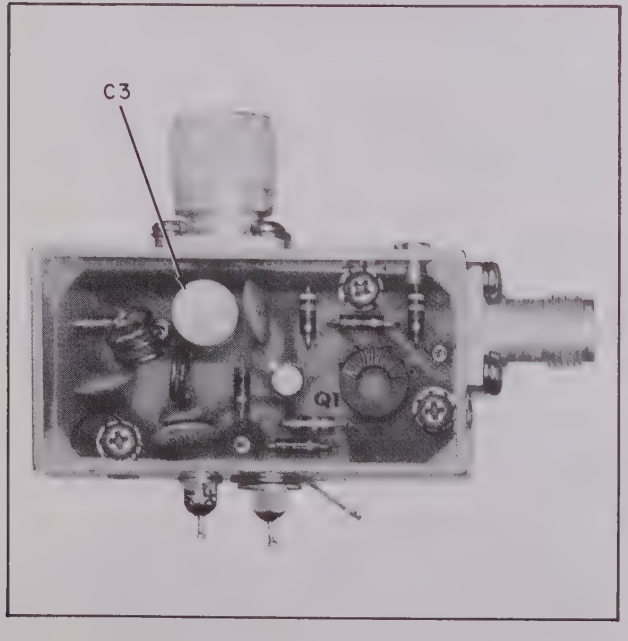


Figure 4-5. 160-MHz Preamplifier A5

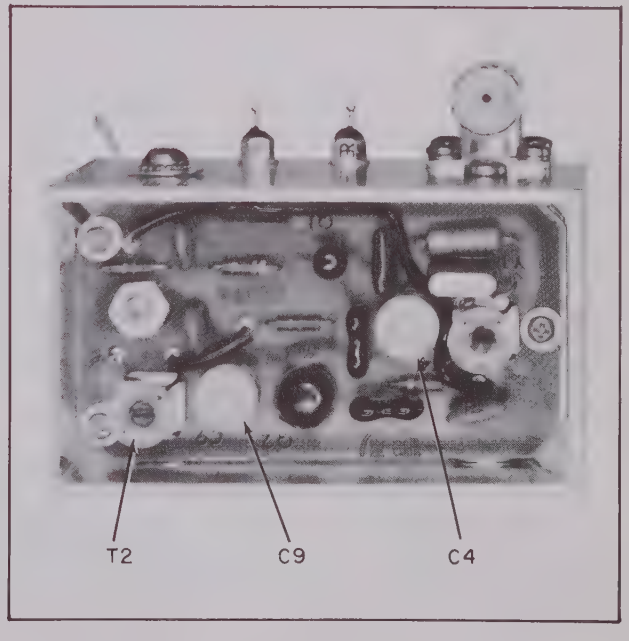


Figure 4-6. Oscillator-Tripler A9 (Oscillator Section)

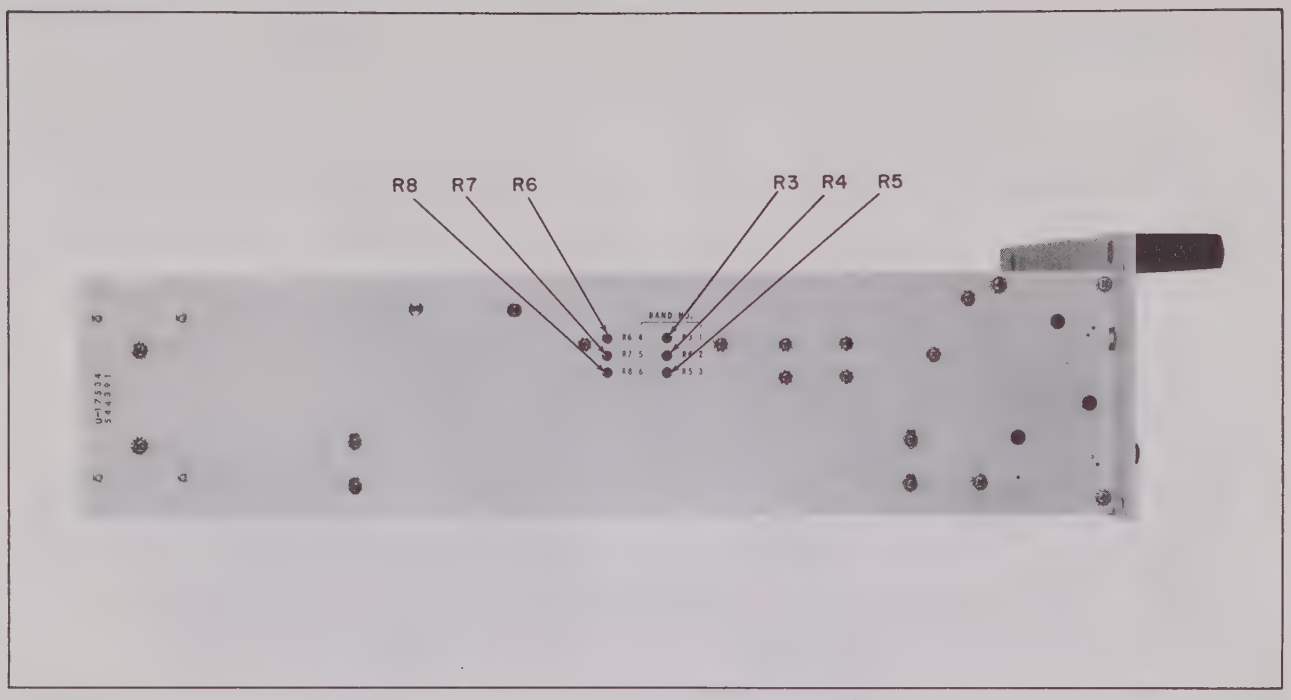


Figure 4-7. RF-100, Top View

4-11. SYSTEMATIC TROUBLE LOCALIZATION.

4-12. The systematic trouble localization techniques employed to maintain both the RF-100 and RF-100A are the same even though additional circuitry is used in the RF-100. Faults are localized down to the assembly board level; and, then, that assembly is replaced. It is not recommended that repairs on Triode Oscillator assembly A3 be attempted in the field; this assembly is best repaired at the factory. Primary sources of trouble are those assemblies which contain active elements, such as 160-MHz Preamplifier assemblies A2 and A5, and Level Amplifier assembly A6, along with the triode oscillator. In addition, when trouble shooting the RF-100, Buffer Amplifier and X8 Frequency Multiplier assembly A8 and 104.167-MHz Oscillator assembly A9 must be added to the list. The discernible symptom (or symptoms) associated with each of the above mentioned assembly boards is, in each instance, related to the characteristics and the availability of the 160 MHz intermediate frequency output at jack J10 for a given signal input. Before performing these procedures, check the sensitivity of the Main Frame. The procedures are as follows:

Note

Before performing any of the detailed procedures, disconnect power plug P2 (tuning head) from plug P3 (main frame), and check the availability of the proper power supply voltage on Plug P3 as follows:

P3-B	-12V
P3-C	+12V
P3-E	+300V
P3-F	+18V

Reconnect the power plug.

4-13. TUNING HEAD INOPERATIVE OVER 1-11 GHZ BANDS.

a. Connect a Hewlett-Packard 536A Frequency Meter to SIGNAL INPUT 11-40 GHZ jack on the tuning unit. In series with the frequency meter, connect a Hewlett-Packard 423A detector and a Simpson Model 260 multimeter.

b. Set SIGNAL FREQUENCY RANGE switch S1 to 26-40 GHz.

c. Adjust the TUNING control to the highest signal frequency, and note the dial indication on the 1-3.5 GHz scale.

d. Tune the frequency meter to 160 MHz above the noted scale frequency and observe a dip on the multimeter; if present, proceed to step f. If no indication occurs (no signal is present), proceed to step e.

e. Connect a direct short across capacitor C1; and check the triode oscillator power output by connecting a 10-dB attenuator, a Hewlett-Packard Model 430C power meter, and a Model 477B

thermister mount to the triode oscillator output jack J1. If a 20 to 100 mw power output is not available, replace the triode oscillator in accordance with the procedure of paragraph 4-31. If the proper output is present with capacitor C1 shorted and not when the short is removed, troubleshoot level Amplifier A6 using the data of table 4-5.

f. Disconnect the miniature coaxial cable on the rear of the main frame, connected between the IF INPUT and IF OUTPUT jacks, and connect a signal generator, capable of generating a 160-MHz signal, to the IF INPUT jack.

g. Apply a 160-MHz signal to the IF INPUT jack and adjust the signal generator output level for -45 dBm and observe the display on the CRT screen.

h. Set SIGNAL FREQUENCY RANGE switch S1 to 0.94 - 3.5 GHz.

i. Disconnect the signal generator without touching the output level controls and reconnect the IF INPUT cable.

j. Disconnect plug P2 from relay K2, and connect the signal generator to jack J1.

k. Apply the same signal generator input used in step g and note that the indication on the main frame display is unchanged. If it changes, replace relay K2 in accordance with the procedures of paragraph 4-32.

l. Disconnect the signal generator without touching the signal generator output level control; reconnect plug P2 of relay K2.

m. Connect the signal generator to the SIGNAL INPUT 1-11 GHz jack and note a nominal 0 dB signal attenuation indicated on the main frame display. If it is present, proceed to the next step; if not, proceed to step o.

n. Disconnect plugs P1 and P2 from relay K1 and perform a continuity check using a dc meter between jacks J1 and J3.

o. Remove crystal from Mixer assembly A1 and check diode CR1, which is removed in accordance with the procedures of paragraph 4-24, with a microwave crystal test set. If the proper readings are not observed, replace the diode. If the proper readings are obtained, troubleshoot 160-MHz Preamplifier assembly A2 in accordance with the data of table 4-3.

4-14. TUNING HEAD INOPERATIVE OVER 11-40 GHZ BANDS ONLY.

a. Disconnect the miniature coaxial cable on the rear of the main frame, connected between the IF INPUT and IF OUTPUT jacks, and connect a signal generator capable of generating a 160-MHz signal to the IF INPUT jack.

b. Apply a 160-MHz signal to the IF INPUT jack and adjust the signal generator output level for -45 dBm and observe the display on the CRT screen.

c. Set SIGNAL FREQUENCY RANGE switch S1 to 11-18 GHz.

d. Disconnect the signal generator without touching the output level controls and reconnect the IF INPUT cable.

e. Disconnect plug P2 from relay K2, and connect the signal generator to jack J2.

f. Apply the same signal generator input used in step b and note that the indication on the main frame display is unchanged. If it changes, replace relay K2 in accordance with the procedures in paragraph 4-32.

g. Disconnect the signal generator without touching the signal generator output level controls, reconnect plug P2 of relay K2.

h. Connect the signal generator to the SIGNAL INPUT 11-40 GHz jack and note that the signal indication on the main frame display is increased by 6 dB. If it is not present, troubleshoot 160 MHz Preamplifier assembly A5 in accordance with the data of table 4-4. If the gain is not 6 dB, perform the alignment procedures of paragraph 4-22. If the signal indication is proper, perform step i.

i. Disconnect plugs P1 and P2 from relay K1 and perform a continuity check using a dc meter between jacks J2 and J3.

4-15. RF-100 INOPERATIVE OVER .01-1 GHZ BAND ONLY. When no signal pip is present, proceed as follows:

a. Disconnect plug P2 from 2.5-GHz bandpass filter FL3 and connect a 10-dB attenuator and a Hewlett-Packard Power Meter, Model 430C, and Thermistor Mount Model 477B to jack J1 of the filter assembly.

b. Observe that a 3 mw power level is available at the 2.5-GHz bandpass filter output jack.

Note

The indicated power level must be increased by 10 dB, the size of the inserted pad, to obtain the power level available at the output jack.

If the proper power level is present, the fault must be in the mixer, isolator, or 2.5-GHz trap FL1; proceed to step c. If it is not, the fault must be either in Oscillator assembly A9 or Buffer Amplifier and X8 Frequency Multiplier assembly A8; then proceed to step d.

c. To troubleshoot the mixer assembly, loosen coupler CP3 on Mixer assembly A7 and check diode CR1, which can be removed in accordance with the procedures of paragraph 4-30, with a microwave crystal test set. If the proper readings are not obtained, replace the diode. If the diode is good, reinsert the diode, secure the screw cap, and refer to the alignment procedures covering 2.5-GHz trap FL1.

d. To troubleshoot the oscillator assembly, disconnect plug P2 from jack J1 of Oscillator assembly A9 and connect a 10-dB pad, and a Hewlett-Packard 430C Power Meter using a HP 477B Thermistor Mount to jack J1. Observe that the output power is approximately 20 mw. If it is not, perform the alignment procedures of paragraph 4-23. If the proper power indication is available, troubleshoot Buffer Amplifier and X8 Frequency Multiplier assembly A8 in accordance with the data of table 4-6.

4-16. When the zero pip of the RF-100, using the .01-1 GHz range, "breaks up" proceed as follows:

Note

The "breaking up" of the zero pip results in the appearance of several pips which assume the position of sidelobes - similar to squegging.

a. Tune the SIGNAL FREQUENCY TUNING dial to 0.

b. Tune X8 Frequency Multiplier Assembly A8 and 2.5-GHz preselector in accordance with the procedures of paragraphs 4-24 and 4-25.

4-17. SENSITIVITY REQUIREMENTS OF A PARTICULAR BAND CANNOT BE MET.

a. Set SIGNAL FREQUENCY RANGE switch S1 to the desired band.

b. Connect the clip-on current probe of Hewlett-Packard Model 428B clip on milliammeter to the white/orange lead of 160-MHz Preamplifier A2 for all bands below 11 GHz or to the white/yellow lead of 160-MHz Preamplifier A5 for all bands above 11 GHz.

c. Check that a current, consistent with the following data, is available; if the proper current is not available, check the resistors as shown.

Range	Milliamps	Check Resistors
0.01-1	0.5	R3 & R11
0.94-3.5	1.2	R4 & R9
3.2-11	3	R5 & R10
11-18	4	R6 & R10
18-26	3	R7 & R10
26-40	3	R8 & R10

4-18. ALIGNMENT AND ADJUSTMENT PROCEDURES.

4-19. Paragraphs 4-20 through 4-26 contain the alignment and adjustment procedures for the RF-100. Because the circuits of the RF-100 are the same as those provided in the RF-100A, except that the RF-100 contains additional circuitry, these procedures are applicable to the RF-100A, also. It is assumed that the proper operating potentials are available from main frame.

4-20. CALIBRATING THE SIGNAL FREQUENCY DIAL. To calibrate the SIGNAL FREQUENCY dial with the output frequency of the triode local oscillator, proceed as follows:

a. With the tuning unit withdrawn from the MF-100, connect the power cables between the main frame and the tuning unit.

b. Set SIGNAL FREQUENCY RANGE switch S1 to the 11-18 GHz position.

c. Connect a Hewlett-Packard 536A Frequency Meter to the SIGNAL INPUT 11-40 GHz jack on the tuning unit. In series with the frequency meter, connect a Hewlett-Packard 423A detector and a Simpson Model 260 Multimeter.

d. Apply power to the MF-100.

e. Adjust the SIGNAL FREQUENCY TUNING control to obtain an indication of 3.5 on the .94-3.5 GHz scale.

f. Check the local oscillator output frequency by tuning the frequency meter for a dip on the multimeter; then set the frequency meter to 3.66 GHz and tune the SIGNAL FREQUENCY TUNING control for a similar multimeter dip.

g. Loosen the set screws fastening the gear to the local oscillator drive shaft without moving the shaft (changing the frequency) and set SIGNAL FREQUENCY TUNING control until the dial scale is set for 3.5 GHz.

h. Tighten the drive shaft gear set screws.

4-21. ALIGNMENT OF PREAMPLIFIER ASSEMBLY A5.

a. Connect the test equipment as shown in figure 4-8.

b. Set SIGNAL FREQUENCY RANGE switch to 11-26 GHz. Remove Attenuator Assembly AT3 (6 dB pad) from Frequency Selective T assembly A4. Then, terminate the unused connector of the T with a termination.

c. Alternately, tune capacitor A5C2 and transformer AST1 to obtain a flat output from 110 to 210

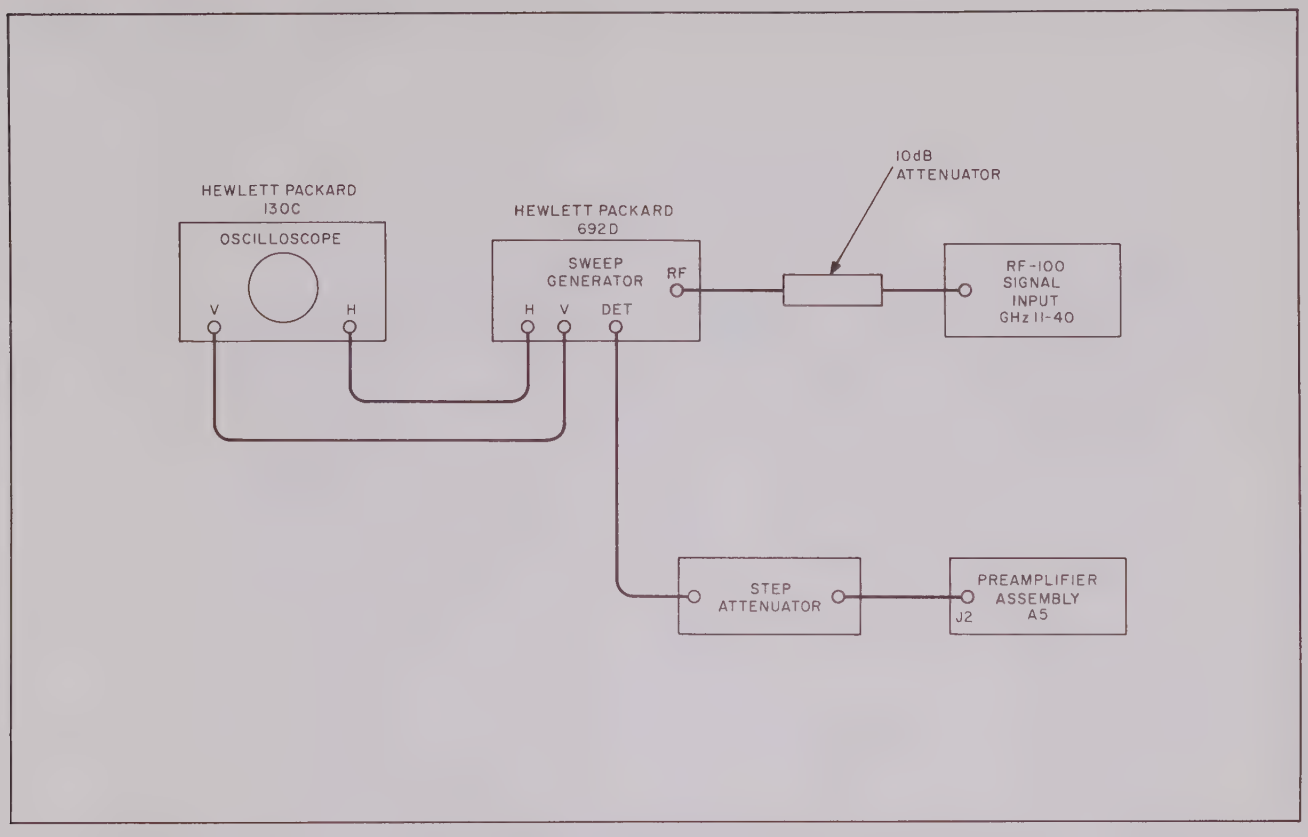


Figure 4-8. Test Setup for Alignment of 160-MHz Preamplifier Assembly A5

MHz (less than 1.5 dB). The gain should be 7 dB minimum, without overdriving the stage to the point where limiting occurs.

d. Remove termination and replace 6 dB pad.

4-22. ALIGNMENT OF PREAMPLIFIER ASSEMBLY A2. Use the test setup of figure 4-8 except that SIGNAL INPUT GHz 1-11 jack is used and 160-MHz preamplifier assembly A2 replaces assembly A5 in the figure.

a. Set SIGNAL FREQUENCY RANGE switch S1 to 0.94-3.5 GHz.

b. Alternately tune capacitor A2C3 and transformers A2T1 and A2T2 for a flat response from 110 to 210 MHz (less than 1.5 dB). The gain should be 0 dB minimum, without overdriving the stage to the point where limiting occurs.

4-23. ALIGNMENT OF OSCILLATOR-TRIPLER ASSEMBLY A9.

a. Connect the test equipment as shown in figure 4-9.

b. Set the power meter range switch to 10 mw, resistance to 200, and the polarity negative.

c. Set the spectrum analyzer controls as follows:

Dispersion	1 MHz/DIV
Freq Range	.01 - 1 GHz
Amplitude Scale	Log

d. Connect a miniature 50 ohms coaxial cable between A9A1TP1 and the sampler.

e. Apply power to the oscillator assembly.

f. Adjust capacitor A9A1C4 to obtain maximum amplitude of the pip at 104 MHz on the analyzer screen.

g. Adjust capacitor A9A1C9 to obtain a maximum indication on the power meter.

h. Adjust transformer A9A1T2 to obtain a maximum indication on the power meter. The minimum indication should be 70 milliwatts.

i. Turn the power to the oscillator off, then on again. Check that the pip height on the analyzer and the power indication on the power meter does not change. If they do, readjust capacitor A9A1C9 for a maximum indication. Then turn off and on again. If the power indication changes, repeat steps f through i.

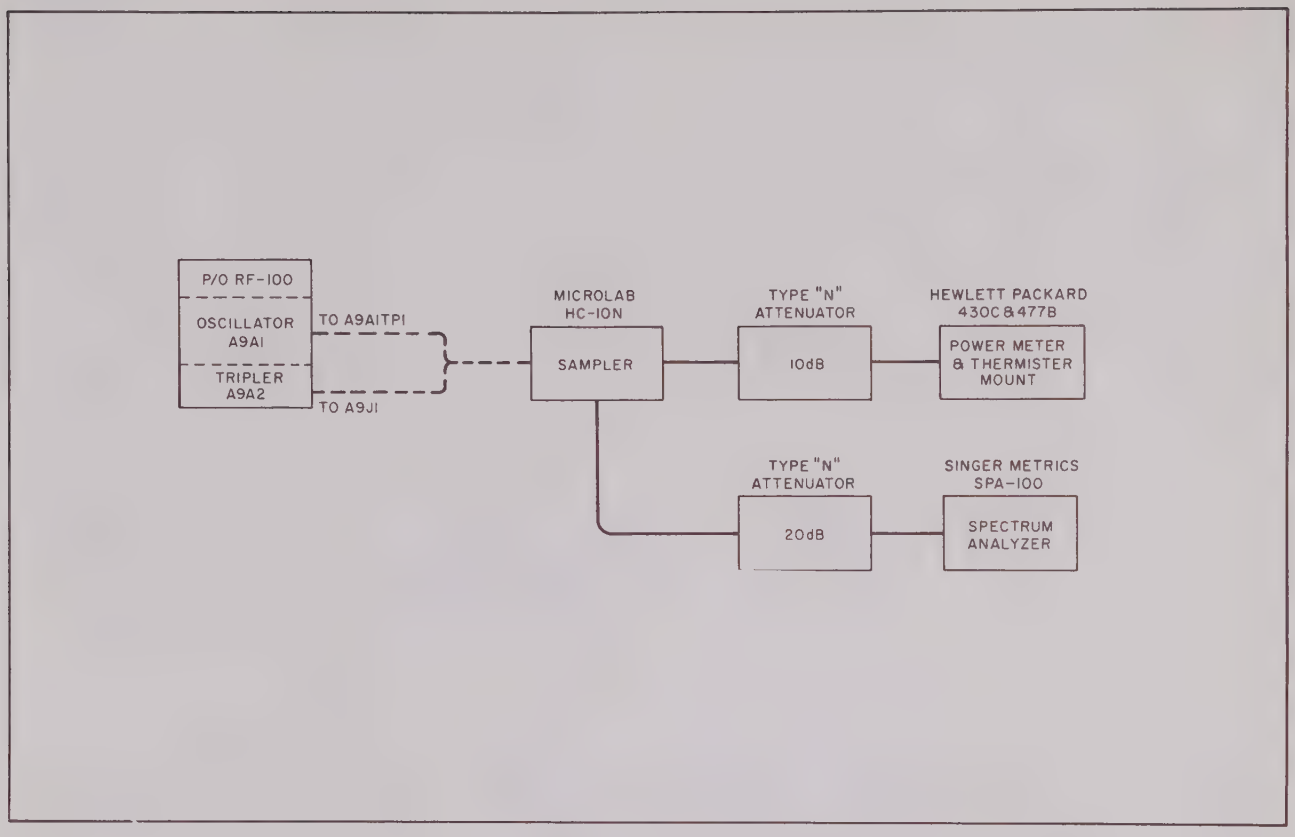


Figure 4-9. Test Setup for Alignment of Oscillator-Tripler Assembly A9

j. Remove power and disconnect the miniature coaxial cable from between the oscillator and sampler, and connect a TNC to BNC cable between the trippler section of assembly A9 and the sampler.

k. Apply power to the oscillator assembly.

l. Set the analyzer to 104 MHz and tune inductor A9A2L4 for a null at 104 MHz. Inductor A9A2L4 should be set to mid range between the two points where the pip reappears on the screen.

m. Set the spectrum analyzer to 208 MHz and tune inductor A9A2L5 for a null at 208 MHz.

n. Set the spectrum analyzer to 312 MHz and tune capacitor A9A2C1 for maximum power on power meter. No secondary pips should appear on analyzer display.

o. Adjust transformer A9A1T2 and capacitor A9A1C9 for maximum power level (note this power level; 20 mw minimum).

p. Turn the power to the oscillator off then on again; the power level should not change. If it does, readjust capacitor A9A1C4 for a maximum power level indication.

q. Readjust capacitor A9A2C1 for a maximum power level indication without the presence of a secondary pip at the signal base.

r. Adjust transformer A9A1T2 and capacitor A9A1C9 for an indication without the presence of a secondary pip at the signal base.

s. Turn the power to the oscillator off and on; the amplitude of the pip displayed on the signal analyzer should not change from the mw power indication noted in step o.

4-24. ALIGNMENT OF 2.5-GHz BUFFER AMPLIFIER AND X8 FREQUENCY MULTIPLIER A8.

a. Connect the equipment as shown in figure 4-10.

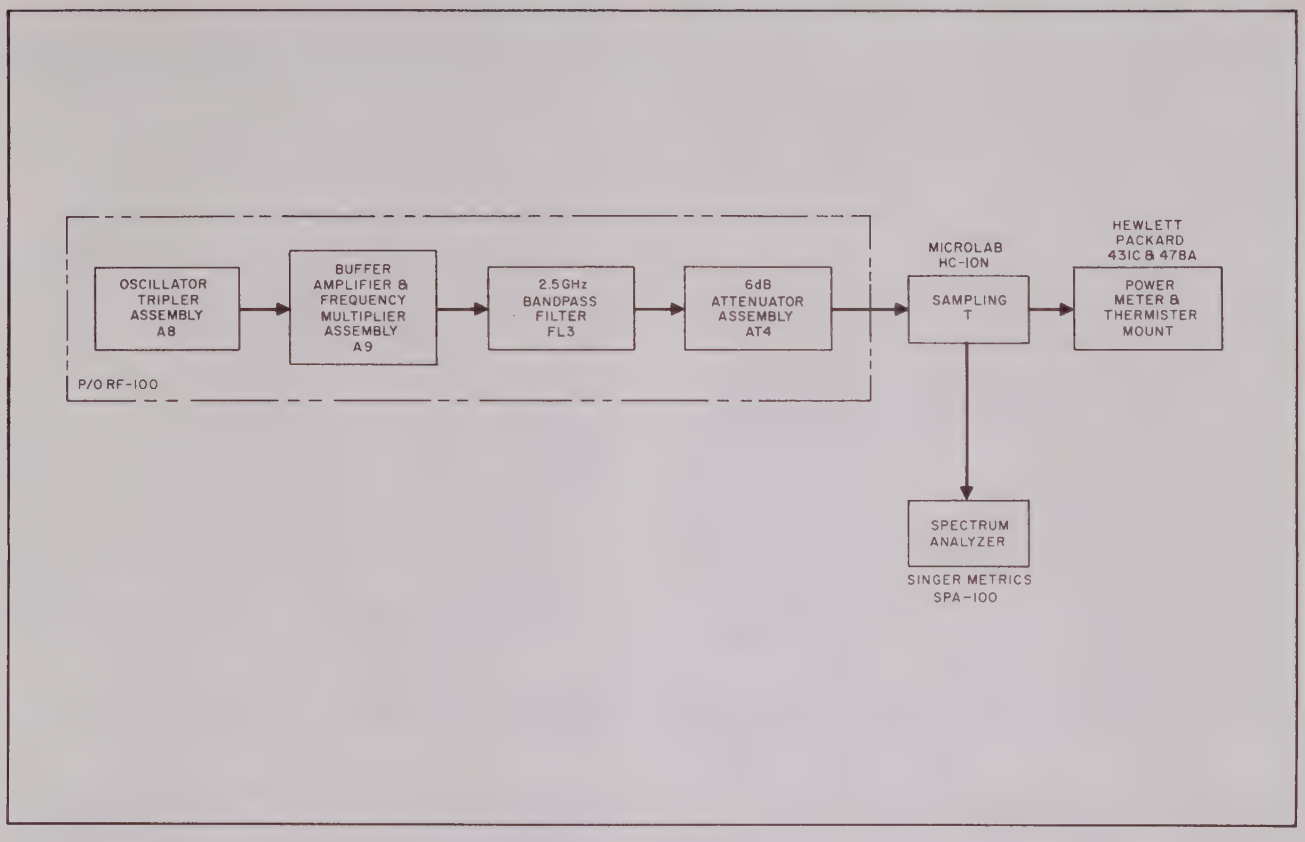


Figure 4-10. Test Setup for Alignment of 2.5-GHz Buffer Amplifier and X8 Frequency Multiplier Assembly A8

b. On the spectrum analyzer, set the following controls:

Dispersion	3 MHz/DIV
Ampltude Scale	Log
IF Bandwidth	Max

c. Set the power meter to the 3 mw range.

d. Turn the cavity trimmer screw of assembly A8 for maximum power.

e. Adjust trimmer capacitor C5 for a maximum power indication (0.9 mw, min).

f. Detune each tuning screw on three-cavity filter FL3 in both directions for a 3-dB variation from resonance. If the signal breaks up because of detuning retune the cavity trimmer screw. Repeak the signal to the power indication of step e after each tuning screw is detuned.

g. Turn off tuning head power; and, after a few minutes reapply power. Check that the response display is unchanged. If it has changed, perform step h.

h. When the proper power requirements cannot be met (0.9 mw) and sustained when power is turned off and on, loosen the 6-32 set screws that hold the body in place in the cavity of assembly A8, and slide the body in or out of the cavity to obtain a maximum power indication at 2.5 GHz. Then repeat steps e through g.

4-25. ALIGNMENT OF 2.5-GHz TRAP ASSEMBLY FL1 and FL3.

a. Connect a signal generator, capable of providing a 10-MHz output, to the SIGNAL INPUT 0.01 GHz input jack; set the signal generator output frequency to 10 MHz.

b. Set the FREQ DISPERSION switch to 10 MHz/DIV.

c. Adjust the SIGNAL FREQ POSITION control to center the zero pip screen; note that the zero pip is bordered by the + and - 10 MHz pips.

d. Adjust the trap tuning capacitors for a minimum zero pip while not permitting any decrease in the +10 MHz pip amplitude.

4-26. ALIGNMENT OF AMPLIFIER ASSEMBLY A6 INPUT CURRENT NETWORK.

a. With the SIGNAL FREQUENCY RANGE switch set to .94 - 3.5 GHz, connect the clip-on current probe of a Hewlett-Packard Model 428B clip-on

milliammeter to the white/orange lead of 160-MHz Amplifier assembly A2.

b. Terminate SIGNAL INPUT .01 - 1 GHz and .94 - 3.5 GHz input jacks with a 10-dB pad and tune through the entire frequency range, find the maximum current indication and set the SIGNAL TUNING control to that frequency.

Note

Steps c and d are to be performed only on the RF-100. The remaining steps apply to both RF-100 and RF-100A.

c. Set SIGNAL FREQUENCY RANGE switch to 0.01 - 1 GHz.

d. Adjust Band 1 potentiometer R3 for a current indication of 0.5 milliamps.

e. Set SIGNAL FREQUENCY RANGE switch to 0.94 - 3.5 GHz.

f. Adjust Band 2 potentiometer R4 for a current indication of 1.2 milliamps.

g. Set SIGNAL FREQUENCY RANGE switch to 3.2 - 11 GHz.

h. Adjust Band 3 potentiometer R5 for a current indication of 3 milliamperes.

i. Terminate the SIGNAL INPUT 11 - 40 GHz input jack with an external mixer and set SIGNAL FREQUENCY RANGE switch to 11 - 18 GHz.

j. Connect the clip-on current probe of Hewlett-Packard Model 428B clip-on milliammeter to the white/yellow lead of 160 MHz amplifier assembly A5.

k. Adjust Band 4 potentiometer R6 for a current indication of 4 milliamps.

l. Set SIGNAL FREQUENCY RANGE switch to 18 - 26 GHz.

m. Adjust Band 5 potentiometer R7 for a current indication of 3 milliamps.

n. Set SIGNAL FREQUENCY RANGE switch to 26 - 40 GHz.

o. Adjust Band 6 potentiometer R8 for a current indication of 3 milliamps.

4-27. PARTS REMOVAL AND REPLACEMENT.

4-28. GENERAL. The replacement of parts within the tuning head is accomplished after the tuning head is removed from the Main Frame. Some of the assemblies in the tuning head are not repairable in the field. These include triode oscillator V1, the tuning dial drive assembly, the band pass filter FL3 and the X8 multiplier of buffer amplifier and X8 frequency multiplier assembly. These assemblies, when careful tests have indicated the need for their repair, should be returned to The Singer Company. They should not be opened for inspection or cleaning or any other reason, but should be removed from the tuning head in strict accordance with the procedures given herein. Parts that are mounted on printed circuit boards can be replaced after the boards have been removed (paragraphs 4-34, 4-35 and 4-36). To remove a part, use a soldering iron with a low power rating (40 watts maximum) and a solder sucker to remove the solder. Because the leads from a part have been crimped during manufacture, it is also necessary to clip the ends of the leads in order to remove the part. After a part has been replaced, check the alignment of the assembly affected by the replacement; after realignment, check the performance standards.

4-29. TUNING HEAD. To remove the tuning head, follow the procedure outlined below:

a. Remove the top and bottom dust covers of the main frame (refer to the Main Frame manual).

b. Remove the five screws that hold the top plate of the tuning head to the frame of the Main Frame.

c. Remove the four screws that hold the front panel of the tuning head to the front panel of the Main Frame.

d. When removing the RF-100, disconnect the input and output cables from the up converter assembly. These are the cables connected to port 1 on the circulator and the lowest cable on the front of the up converter assembly.

e. Pull the tuning head out of the Main Frame far enough (approximately 4 inches) to gain access to the IF output connector, which is the gold-plated connector attached to coaxial relay K2.

f. Disconnect the IF output connector from coaxial relay K2.

g. Disconnect power connector P2 of the tuning head from mating connector P3 of the Main Frame.

h. Complete the withdrawal of the tuning head from the Main Frame.

4-30. MIXER CRYSTALS. To remove the crystal diodes from the .01-1 GHz mixer, perform steps a and b; to remove the crystal from the 1-11 GHz mixer, perform steps c through f; and to remove the crystal from the accessory mixers, perform steps g through i.

a. To replace the crystal in the 0.01-1 GHz mixer, unscrew W4P1 from coupler CP3. Unscrew coupler CP3 from mixer A7 and, grasping the special holder attached to the exposed contact of the diode, remove the defective diode with its insulating ring.

b. Place the insulating ring and holder over the anode end of the replacement diode (Microwave Assoc. MA417) and insert into the mixer. Replace CP3 and connect W4P1 to CP3.

c. To replace the crystal in the 1-11 GHz mixer, remove the two screws that secure 160-MHz preamplifier A2 to its mounting strip.

d. Unscrew A2J1 from mixer A1.

e. Withdraw the defective diode and insert a replacement 1N1132.

f. Perform steps e through c in reverse.

g. To replace the crystal in a Model K_u-100, K-100 or K_a-100 Waveguide Mixer, unscrew the knurled body from the waveguide.

h. Remove the defective diode and insert a replacement crystal, as required.

Mixer	Diode Type
K_u-100	1N4605
K-100	1N26
K_a-100	1N53

i. Screw the knurled body to the waveguide. After the crystal has been replaced, check the mixer for sensitivity. If the sensitivity specification cannot be met, it will be necessary to rotate the crystal in its seat. This procedure may have to be repeated several times until proper sensitivity is attained.

4-31. TRIODE OSCILLATOR. Do not attempt repairs on this assembly. The assembly must be removed in accordance with the instructions given below and then shipped to The Singer Company for repair.

a. Remove the four screws that hold the triode oscillator assembly to the top plate of the tuning head.

b. Pull the triode oscillator assembly slightly away from the top plate to gain access to the three soldered connections. Unsolder the plate connection near the front-panel end of the assembly and the two filament connections at the rear of the assembly.

c, Loosen the two setscrews in the gear on the shaft of the assembly and remove and retain the gear for use with the replacement assembly.

4-32. COAXIAL RELAYS. Either coaxial relay can be removed by following the procedure given below:

a. Disconnect the three coaxial cables from the relay.

b. Remove the two screws that hold the relay to the top plate of the tuning head.

c. Unsolder the leads to the coil of the relay, and remove the relay.

4-33. REGULATOR ASSEMBLY. To gain access to any of the parts of the regulator assembly (the six bias adjustments and the two zener regulators for the triode oscillator), follow the procedures given below:

a. In the RF-100, remove the input and output cables to the 2. 5-GHz bandpass filter.

b. Remove the two screws and lockwashers that secure the regulator assembly to the top plate of the tuning head.

4-34. LEVEL AMPLIFIER. To remove the level amplifier printed circuit board, remove the two screws that hold the mounting brackets to the casting, and raise up the printed circuit board.

4-35. 160 MHz PREAMPLIFIERS. To gain access to the parts within the 160 MHz preamplifiers, follow the procedure given below:

a. Remove the two screws that secure the preamplifier to the strap that joins both preamplifiers.

b. Disconnect the preamplifier associated with the 11-40 GHz input from its associated mixer. Move this preamplifier as far away from the other preamplifier as its wired connections permit.

c. Remove both side plates of the preamplifier requiring repairs by removing the four screws that secure each plate to the preamplifier body. The parts on the printed circuit board are now accessible.

4-36. OSCILLATOR-TRIPLER ASSEMBLY. To gain access to the parts on the printed circuit boards of the oscillator-tripler assembly, follow the procedure below:

a. Remove the four bolts that secure the top plate of the assembly to the bottom plate, and remove the top plate.

b. Rotate the body of the oscillator-tripler assembly to expose the wiring at the bottom of the assembly.

c. Unsolder the wiring to the feed-thru capacitors and connector, but do not remove these components.

d. Remove the four screws and lockwashers that hold the mounting brackets to the oscillator-tripler assembly body.

e. Remove the printed circuit boards and the mounting brackets through the top of the assembly.

f. Unscrew the board on which the part to be replaced is mounted from the mounting brackets.

g. Unsolder the -12 volt and +12 volt leads from the board to be removed; do not unsolder the coaxial connection between the two boards.

h. Separate the two boards by rotating them

about the coaxial connection only to the extent needed to gain access to the soldering connection.

Note

During reassembly, it might be necessary to remove the solder from the +12 and -12 volt connection holes so that the wires easily slip into the holes when the boards are rotated back into the original position.

4-37. 2.5-GHz BANDPASS FILTER. To remove the 2.5-GHz bandpass filter, follow the procedure below:

a. Remove the regulator assembly from the top plate of the tuning head (paragraph 4-33).

b. Remove the four screws from the bottom of the regulator assembly that hold the 2.5-GHz bandpass filter, and remove the filter.

4-38. X8 MULTIPLIER. To remove the X8 multiplier, remove the input and output coaxial connectors, and remove the three screws that secure it to the top plate of the tuning head.

4-39. VOLTAGE MEASUREMENTS.

4-40. To facilitate troubleshooting and repair of the circuit assemblies, tables 4-3 through 4-8 provide nominal emitter, base, and collector voltage levels that should be available for the referenced transistor. Each table provides the data associated with a particular circuit assembly board. If an assembly is not referenced it is because no transistors are located on that board. Note that all voltages are measured with respect to ground using a vtvm.

TABLE 4-3. VOLTAGE MEASUREMENTS, 160-MHz PREAMPLIFIER A2

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	Fairchild FT-45	-10.5	-10	0

Note: SIGNAL FREQUENCY RANGE switch set to 1-3.5 GHz.

TABLE 4-4. VOLTAGE MEASUREMENTS, 160-MHz PREAMPLIFIER A5

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	Fairchild FT-45	-10.5	-10	0

Note: SIGNAL FREQUENCY RANGE switch set to 11-18 GHz.

TABLE 4-5. VOLTAGE MEASUREMENTS, LEVEL AMPLIFIER A6

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3440	+0.8	+1.5	50
Q2	2N3694	-0.6	-0.1	+1.5
Q3	2N3694	-0.6	-0.1	+12

TABLE 4-6. VOLTAGE MEASUREMENTS, BUFFER AMPLIFIER AND X8 FREQUENCY MULTIPLIER A8

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N4427	-0.5	0	+12

TABLE 4-7. VOLTAGE MEASUREMENTS, 104.167-MHz OSCILLATOR A9

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
A1Q1	2N3563	-0.5	0	+ 5
A1Q2	2N3642	-0.5	0	+12
A2Q1	2N3866	-12	-12	+12

SECTION V
SCHEMATIC DIAGRAMS

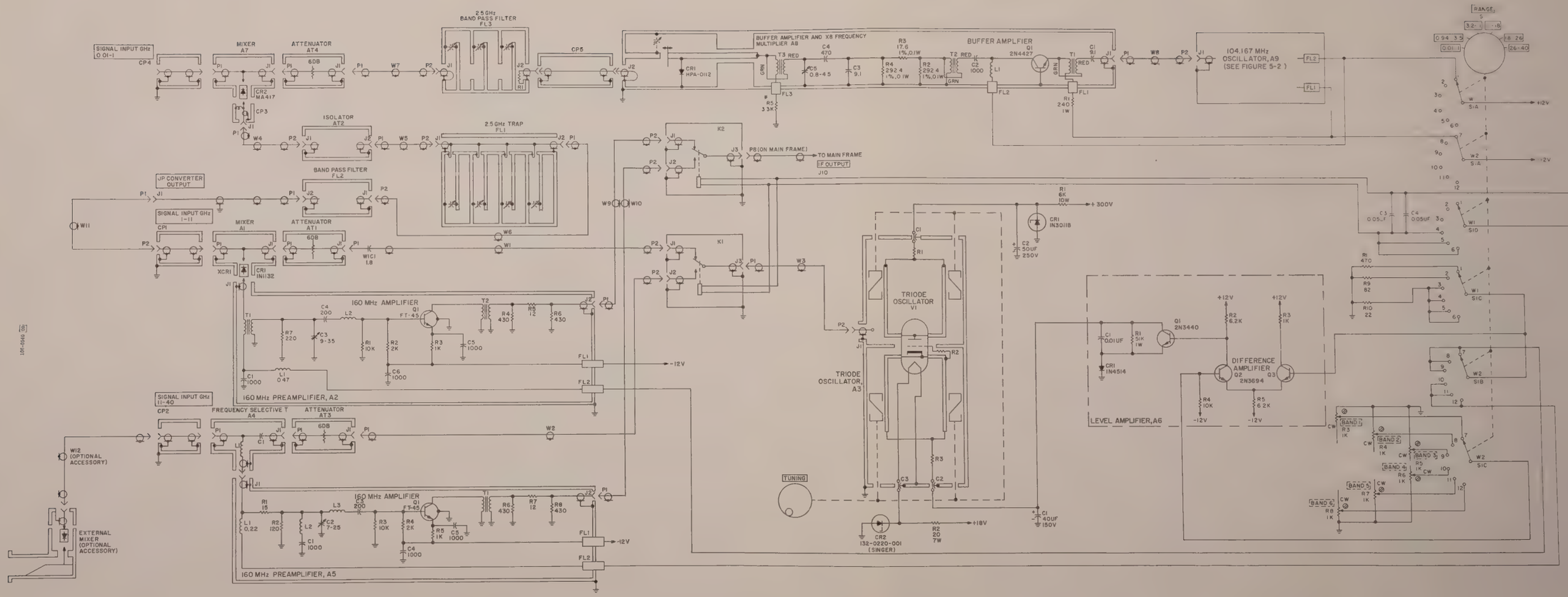
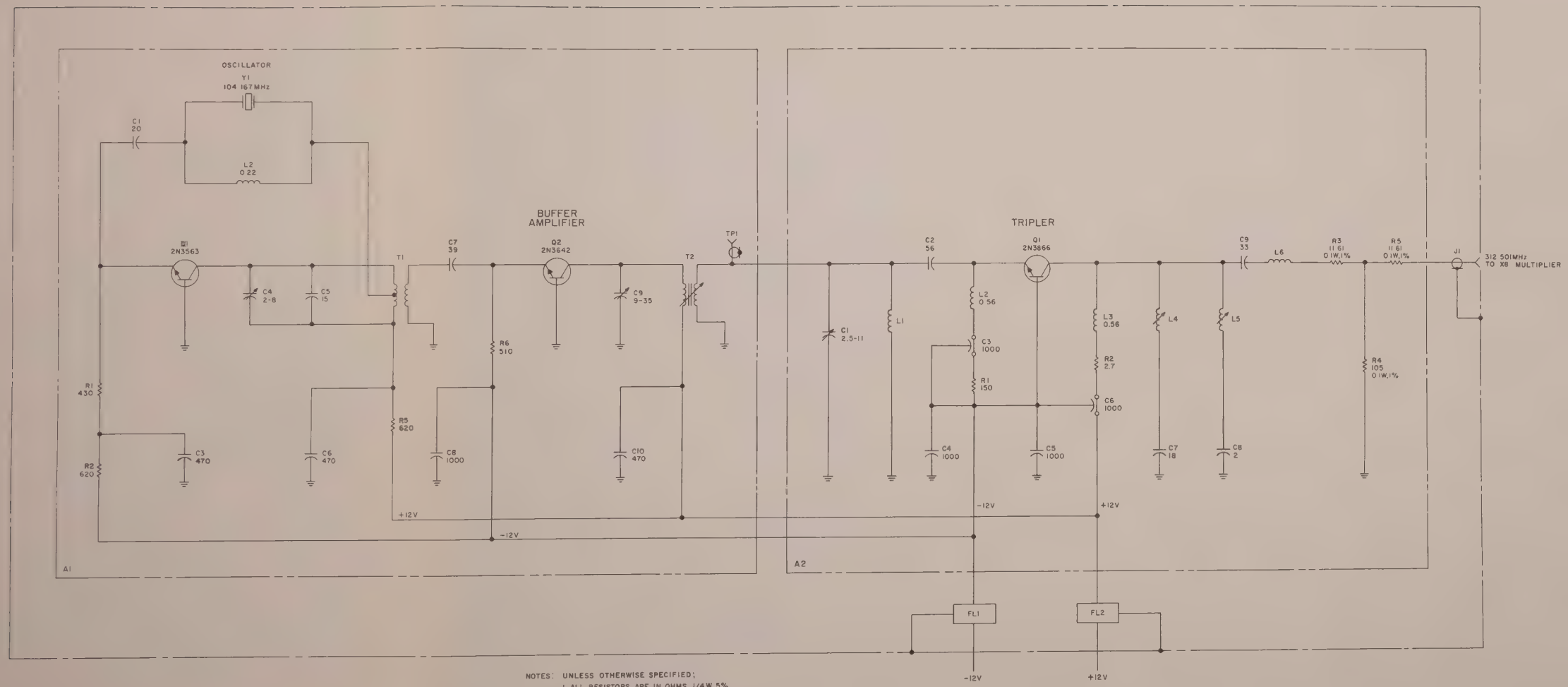


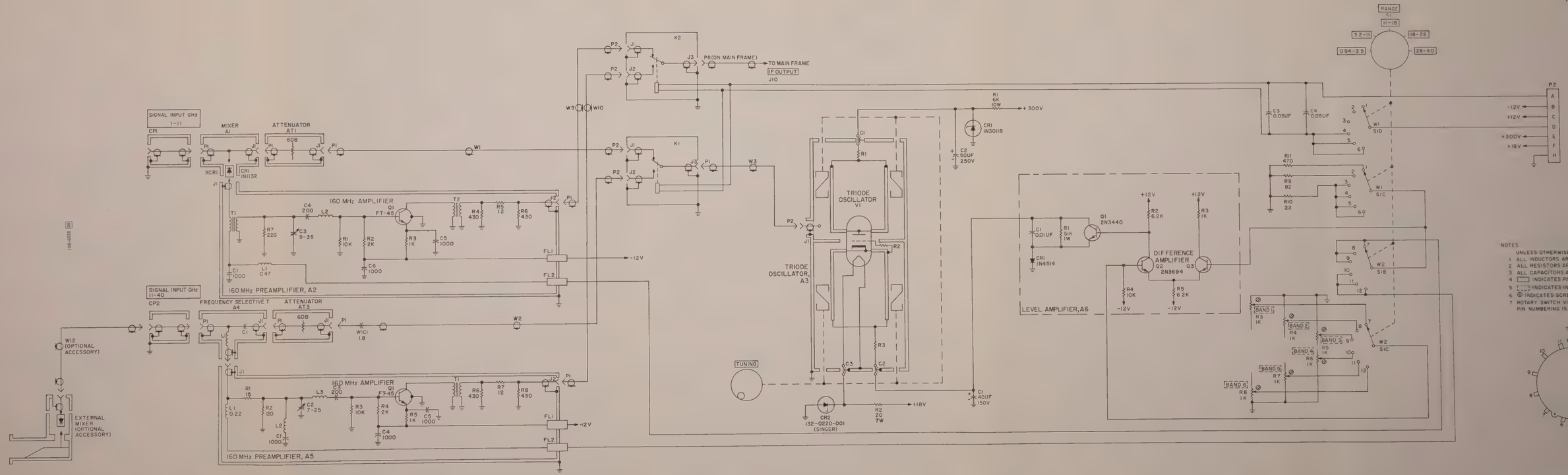
Figure 5-1. Model RF-100 Tuning Head Schematic Diagram



NOTES: UNLESS OTHERWISE SPECIFIED;
1. ALL RESISTORS ARE IN OHMS, 1/4W, 5%
2 ALL CAPACITORS ARE IN PICOFARADS
3. ALL INDUCTORS ARE IN MICROHENRIES

106-0537 [04]

Figure 5-2. 104.167-MHz Oscillator and Frequency Frequency Tripler A9, Schematic Diagram



NOTES
UNLESS OTHERWISE SPECIFIED
1 ALL INDUCTORS ARE IN MICROHENRIES
2 ALL RESISTORS ARE IN OHMS, 1/4W, 5%
3 ALL CAPACITORS ARE IN PICOFARADS
4 ⬜ INDICATES PANEL MARKING
5 ⬚ INDICATES INTERNAL MARKING
6 Ⓢ INDICATES SCREWDRIVER ADJUSTMENT
7 ROTARY SWITCH VIEWED FROM SHAFT END
PIN NUMBERING IS SHOWN BELOW

Figure 5-3. Model RF-100A Tuning Head Schematic Diagram

SECTION VI
PARTS LIST

6-1. INTRODUCTION

6-2. This parts list section includes all pertinent data necessary to locate, identify, and procure additional parts for the equipment. Parts are listed alpha-numerically by reference symbol and include all replaceable items such as electronic, electro-mechanical, and mechanical parts of the equipment. In some cases, values, ratings and manufacturer sources shown are nominal and variations may be found. Satisfactory replacement may be made with either the listed component or an exact replacement of the part(s) removed from the equipment.

6-3. ORDERING INFORMATION

6-4. The following instructions will aid in ordering parts from the Parts Lists, tables 6-2 through 6-4.

a. Address all inquiries or orders to:

CUSTOMER SERVICE
Department 50
The Singer Company
Metrics Division
915 Pembroke Street
Bridgeport, Connecticut, 06608

b. Include the following information:

1) Model and Serial Number of instrument.

2) Singer Part Number.

3) Reference Symbol Number.

4) Description (as shown on list).

6-5. HOW TO USE THE PARTS LIST

6-6. Paragraphs 6-7 through 6-11 describe the use and meaning of the five columns included in the parts list (see figure 6-1).

6-7. REF SYMBOL COLUMN. The Ref Symbol Column (1, figure 6-1) contains an alpha-numerical listing of parts as they appear on equipment chassis, illustration, or schematic. The reference designation identifies the parts as to their component function in the instrument.

6-8. DESCRIPTION COLUMN. The Description Column (2, figure 6-1) contains the identification of component parts including all pertinent specifications and Singer part number. When the description column is used for a part which is identical to a part which has already been described; SAME AS (3) is used along with the reference symbol of the previously used part. In these instances, columns 3, 4, 5 are left blank. When the description column is used for a reference symbol for which no part exists; NOT USED (4) is placed in the column. In these instances, columns 3, 4, 5, are left blank.

6-9. MANUFACTURER'S PART NUMBER COLUMN. The Manufacturer's Part Number column (5, figure 6-1) contains the part number as designated by the manufacturer of the part.

6-10. MFR'S CODE COLUMN. The Mfr's Code column (6, figure 6-1) references the manufacturer by an assigned code number as listed in Federal Supply Code Handbook H4-2. For manufacturers not listed in H4-2, a letter code will be assigned. Table 6-1 includes the manufacturer and his code designation.

6-11. MAINT QTY COLUMN. The Maint Qty column (7, figure 6-1) contains the number of additional components recommended to keep the equipment at an optimum performance level. The recommended number of components in the Maint Qty column is based on 2000 hours of equipment operation.

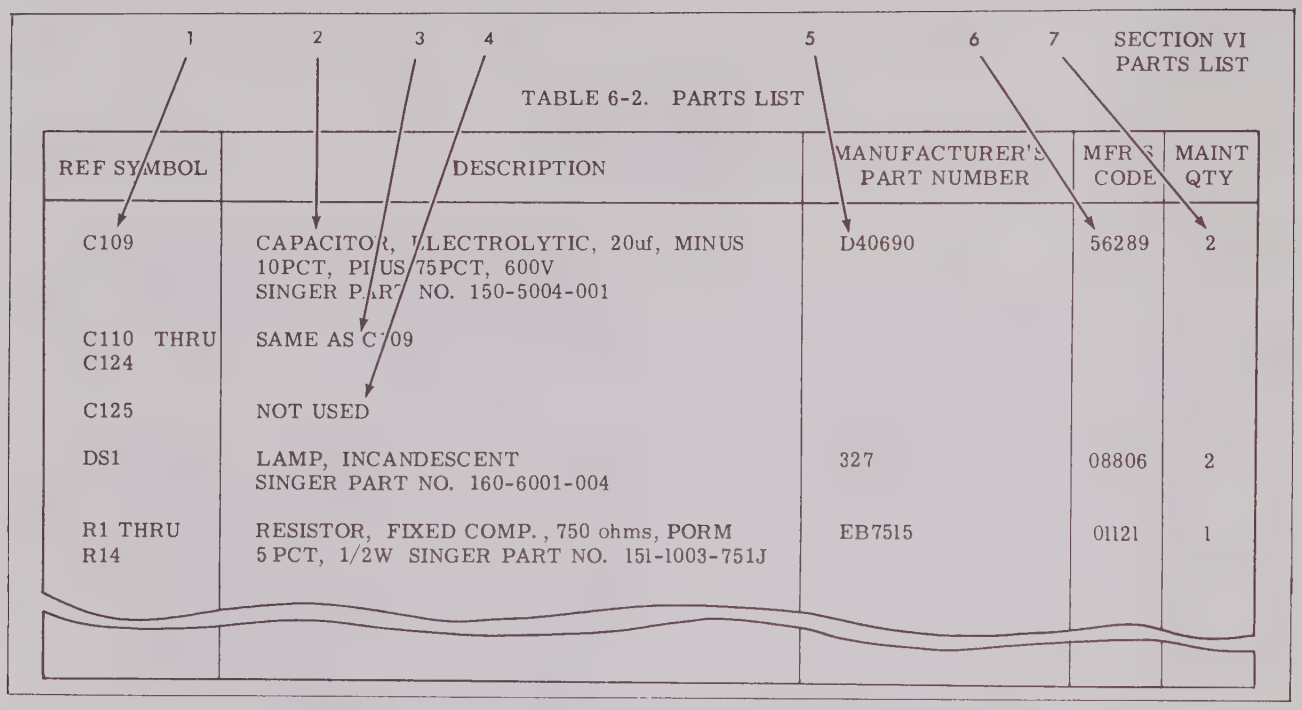


Figure 6-1. Parts List Sample

TABLE 6-1. MANUFACTURER'S CODE

Number	Name
INSTD	Industry Standard
01121	Allen-Bradley Co. Milwaukee, Wis.
01295	Texas Instruments, Inc. Dallas, Texas
02660	Amphenol-Borg Electronics Corp. Maywood, Ill.
02735	Radio Corp. of America Solid State and Receiving Tube Division Somerville, N.J.
04713	Motorola Inc. Semiconductor Products Division Phoenix, Arizona
07263	Fairchild Camera and Instrument Corp. Semiconductor Division Mountain View, Calif.
16665	The Singer Company Metrics Division Bridgeport, Conn.
28480	Hewlett-Packard Co. Palo Alto, Calif.
56289	Sprague Electric Co. North Adams, Mass.
63743	Ward Leonard Electric Co. Mount Vernon, N.Y.
71590	Centralab Division of Globe-Union Inc. Milwaukee, Wis.
72136	Electro-Motive Mfg. Co., Inc. Willimantic, Conn.
72982	Erie Technological Products Inc. Erie, Pa.
74970	E.F. Johnson Co., Waseca, Minn.
78488	Stackpole Carbon Co., St. Marys, Pa.
78526	Stanwyck Winding Co., Inc. Newburgh, N.Y.
79089	Radio Corp. of America Solid State and Receiving Tube Division Harrison, N.J.
81349	Military Specifications
91637	Dale Electronics, Inc., Columbus, Nebr.
91737	Gremar Electronics, Inc., Wakefield, Mass.
96341	Microwave Associates Burlington, Mass.
98291	Sealectro Corp., Mamaroneck, N.Y.

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
AT1	ATTENUATOR, 6 DB	134-0022-001	16665	1
AT1J1	CONNECTOR,JACK,NON-REPLACEABLE PART OF AT1			
AT1P1	CONNECTOR,PLUG,NON-REPLACEABLE PART OF AT1			
AT2	ISOLATOR	556146662	16665	1
AT2J1 AND J2	CONNECTOR,JACK,NON-REPLACEABLE PART OF AT2			
AT3 AND AT4	SAME AS AT1			
AT3J1	CONNECTOR,JACK,NON-REPLACEABLE PART OF AT3			
AT3P1	CONNECTOR,PLUG,NON-REPLACEABLE PART OF AT3			
AT4J1	CONNECTOR,JACK,NON-REPLACEABLE PART OF AT4			
AT4P1	CONNECTOR,PLUG,NON-REPLACEABLE PART OF AT4			
CP1 AND CP2	MIXER ADAPTER ASSY	556146-969	16665	1
CP3	MIXER ADAPTER ASSY	103-1633-001	16665	1
CP3J1	CONNECTOR,JACK,NON-REPLACEABLE PART OF CP3			
CP4	SAME AS CP1			
CP5	ADAPTER,RIGH ANGLE SINGER PART NO. 556146-995	6017	91737	1
CR1	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556118-140	1N3011	04713	1
CR2	SEMICONDICTOR DEVICE,DIODE	132-0220-001	16665	1
C1	CAPACITOR,FIXED,ELECTROLYTIC, 40 UF, 150VDCW SINGER PART NO. 556147-228	39D406F150EL4	56289	1
C2	CAPACITOR,FIXED,ELECTROLYTIC 50UF, 250V SINGER PART NO. 556147-210	39D506F250JE4	56289	1
FL1	205 GHZ TRAP ASSY	103-1581-001	16665	1
FL1J1 AND J2	CONNECTOR,JACK,NON-REPLACEABLE PART OF FL1			
FL2	FILTER,BANDPASS	556146-663	16665	1
FL2J1 AND J2	CONNECTOR,JACK,NON-REPLACEABLE PART OF FL2			
FL3	FILTER,BANDPASS	103-1579-001	16665	1
FL3J1 AND J2	CONNECTOR,JACK,NON-REPLACEABLE PART OF FL3			
FL3R1	RESISTOR,NON-REPLACEABLE PART OF FL3			
J1	CONNECTOR,JACK SINGER PART NO. 556146-233	6030	91737	1
K1	RELAY,COAXIAL SINGER PART NO. 556146-903	360-11892-48	02660	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
K1J1 THRU J3	CONNECTOR,JACK,NON-REPLACEABLE PART OF K1			
K2	RELAY,COAXIAL SINGER PART NO. 556146-907	315-10049-8	02660	1
K2J1 THRU J3	CONNECTOR,JACK,NON-REPLACEABLE PART OF K2			
L2	INDUCTOR	132-0321-001	16665	
P1	CONNECTOR,PLUG SINGER PART NO.168-4038-001	6001/NONTARN	91737	1
P2	CONNECTOR,PLUG, 7 PIN, W/HOOD AND CLAMP SINGER PART NO. 556016-061	126-195	02660	1
R1	RESISTOR FIXED,WIRE-WOUND,6.0K OHMS,PORM 5 PCT,10W SINGER PART NO. 161-2003-602J	10XM6000	63743	1
R2	RESISTOR FIXED,WIRE-WOUND, 20 OHMS, PORM 5 PCT,7W SINGER PART NO. 556146-936	244E2005	56289	1
R3 THRU R8	RESISTOR,VARIABLE, 1K OHM,PORM 10 PCT,1/2W SINGER PART NO. 556204-203	2389-1K	91637	1
R9	RESISTOR FIXED,COMP., 82 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-820J	CB8205	01121	1
R10	RESISTOR FIXED,COMP., 22 OHMS,PORM 5 PCT 1/4W SINGER PART NO. 151-1002-220J	CB2205	01121	1
R11	RESSITOR,FIXED,COMP., 470 OHMS PORM 5PCT SINGER PART NO. 151-1002-471J	CB4715	01121	1
S1	SWITCH,ROTARY, 6 POS.	133-0091-001	16665	1
W1	CABLE ASSY	102-9200-400	16665	1
W1C1	CAPACITOR,FIXED,COMP., 1.8PF PORM 10PCT 500V SINGER PART NO. 150-4001-1R8K	GA1.8PFPORM10PCT	78488	1
W1P1	CONNECTOR,PLUG	149-0177-001	16665	1
W1P2	CONNECTOR,PLUG SINGER PART NO.168-4038-001	6001	91737	1
W2	CABLE ASSY	102-9200-300	16665	1
W2P1	CONNECTOR,PLUG SINGER PART NO. 556146-974	6039	91737	1
W2P2	SAME AS W1P2			
W3	CABLE ASSY	102-9112-004	16665	1
W3P1 AND P2	SAME AS W1P2			
W4	CABLE ASSY	102-9200-304	16665	1
W4P1 AND P2	SAME AS W2P1			
W5	CABLE ASSY	102-9112-002	16665	1
W5P1 AND P2	SAME AS W1P2			
W6	SAME AS W5			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
W6P1 AND P2	SAME AS W1P2			
W7	CABLE ASSY	102-9200-302	16665	1
W7P1	SAME AS W2P1			
W7P2	SAME AS W1P2			
W8	CABLE ASSY	102-9200-303	16665	1
W8P1	SAME AS W2P1			
W8P2	SAME AS W1P2			
W9	CABLE ASSY	102-9112-003	16665	1
W9P1 AND P2	SAME AS W1P2			
W10	SAME AS W9			
W10P1 AND P2	SAME AS W1P2			
W11	SAME AS W5			
W11P1 AND P2	SAME AS W1P2			
A1	MIXER ASSY	134-0018-001	16665	1
A1CR1	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556146-342	1N1132	81349	1
A1J1	CONNECTOR,JACK,NON-REPLACEABLE PART OF A1			
A1P1	CONNECTOR,PLUG,NON-REPLACEABLE PART OF A1			
A2	160 MHZ PREAMPLIFIER ASSY	103-1593-001	16665	1
A2C1	CAPACITOR,FIXED,CERAMIC DISC, 0.001 UF,PORM 5 PCT,1000V SINGER PART NO. 556060-046	DD-102	71590	2
A2C2	CAPACITOR,FIXED,DIPPED MICA, 20 PF,PORM 5 PCT,500V SINGER PART NO.150-2002-200EJO	DM15E200J0500WV4CR	72136	1
A2C3	CAPACITOR,VARIABLE,CERAMIC 9TO35PF SINGER PART NO. 150-0008-008	538-011D9-35	72982	
A8C3	SAME AS A8C1			
A2C4	CAPACITOR,FIXED,CERAMIC DISC, 200PF,1000V SINGER PART NO. 556146-696	DD201	71590	1
A2C5 AND C6	SAME AS A2C1			
A2FL1 AND FL2	FILTER,FEED-THRU SINGER PART NO. 556146-774	1270-016	72892	1
A2J1	CONNECTOR,JACK	103-1619-001	16665	1
A2J2	CONNECTOR,JACK SINGER PART NO. 556146-629	6014	91737	1
A2L1	INDUCTOR,SHIELDED, 0.47 SINGER PART NO. 556200-002	DINK 0.47	78526	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2L2	INDUCTOR	132-0321-001	16665	1
A2Q1	TRANSISTOR SINGER PART NO. 556146-739	FT45	07263	1
A2R1	RESISTOR FIXED,COMP., 10K OHMS,PORM 5 PCT, 1/4 W SINGER PART NO. 151-1002-103J	CB1035	01121	1
A2R2	RESISTOR FIXED,COMP., 2K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-202J	CB2025	01121	1
A2R3	RESISTOR FIXED,COMP., 1K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-102J	CB1025	01121	1
A2R4	RESISTOR FIXED,COMP., 430 OHMS,PORM 5PCT, 1/4W SINGER PART NO. 151-1002-431J	CB4315	01121	2
A2R5	RESISTOR FIXED,COMP., 12 OHMS,PORM 5 PCT, 1/4 W SINGER PART NO. 151-1002-120J	CB1205	01121	1
A2R6	SAME AS A2R4			
A2T1	TRANSFORMER	132-0265-001	16665	1
A2T2	TRANSFORMER	132-0266-001	16665	
A3	TRIODE OSCILLATOR ASSY	110-0244-001	16665	1
A3C1 THRU C3	CAPACITOR,NON-REPLACEABLE PART OF A3			
A3J1	CONNECTOR,JACK,NON-REPLACEABLE PART OF A3			
A3R1 THRU R3	RESISTOR,NON-REPLACEABLE PART OF A3			
A3V1	TRIODE OSCILLATOR,NON-REPLACEABLE PART OF A3			
A4	TEE FREQUENCY SELECTIVE ASSY	134-0020-001	16665	1
A4C1	CAPACITOR,NON-REPLACEABLE PART OF A4			
A4J1	CONNECTOR,JACK,NON-REPLACEABLE PART OF A4			
A4L1	COIL,NON-REPLACEABLE PART OF A4			
A4P1	CONNECTOR,PLUG,NON-REPLACEABLE PART OF A4			
A5	160 MHZ PREAMPLIFIER	103-1594-001	16665	1
A5C1	SAME AS A2C1			
A5C2	CAPACITOR,VARIABLE, 7 TO 25 PF SINGER PART NO. 150-0008-004	538-011B7-25	72982	1
A5C3	SAME AS A2C4			
A5C4 AND C5	SAME AS A2C1			
A5FL1 AND FL2	SAME AS A2FL1			
A5J1	CONNECTOR,JACK SINGER PART NO. 556146-927	6049	91737	1
A5J2	SAME AS A2J2			
A5L1	INDUCTOR,SHIELDED, 0.22 UH SINGER PART NO. 556200-001	DINK 0.22	78526	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A5L2	INDUCTOR	132-0260-001	16665	1
A5L3	INDUCTOR	132-0262-001	16665	1
A5Q1	SAME AS A2Q1			
A5R1	RESISTOR FIXED,COMP., 15 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-150J	CB1505	01121	1
A5R2	RESISTOR FIXED,COMP., 120 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-121J	CB1215	01121	U
A5R3	SAME AS A2R1			
A5R4	SAME AS A2R2			
A5R5	SAME AS A2R3			
A5R6	SAME AS A2R4			
A5R7	SAME AS A2R5			
A5R8	SAME AS A2R4			
A5T1	TRANSFORMER	132-0266-001	16665	1
A6	LEVEL AMPLIFIER ASSY	103-1576-001	16665	1
A6CR1	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556146-195	1N4514	81349	1
A6C1	CAPACITOR,FIXED,CERAMIC DISC, 0.01 UF,PLUS 60 MINUS 40 PCT,250V SINGER PART NO. 556060-146	DA140-172B	71590	1
A6Q1	TRANSISTOR SINGER PART NO. 556146-673	2N3440	79089	
A6Q2 AND Q3	TRANSISTOR SINGER PART NO. 556146-677	2N3694	79089	1
A6R1	RESISTOR,FIXED,COMP., 51K OHMS, PORM 5 PCT, IW SINGER PART NO. 151-1004-513J	GB5135	01121	
A6R2	RESISTOR FIXED,COMP., 6.2K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-622J	CB6225	01121	1
A6R3	SAME AS A2R3			
A6R4	SAME AS A2R1			
A6R5	SAME AS A6R2			
A7	MIXER ASSY	134-0019-001	16665	1
A7CR2	SEMICONDUCTOR,DEVICE,DIDE SINGER PART NO. 556146-740	MA417	96341	1
A7J1	CONNECTOR,JACK,NON-REPLACEABLE PART OF A7			
A7P1	CONNECTOR,PLUG,NON-REPLACEABLE PART OF A7			
A8	MULTIPLIER ASSY	103-1582-001	16665	1
A8CR1	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556147-004	HPA-0112	28480	1
A8C1	CAPACITOR,FIXED,COMP., 9.1 PF,PORM 5 PCT, 500V SINGER PART NO. 150-4001-9R1J	GA/9.1PF500VPORM5PCT	78488	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A8C2	CAPACITOR,FIXED,CERAMIC, 1000 PF SINGER PART NO. 556147-005	B-16-102W	01121	1
A8C4	CAPACITOR,FIXED,CERAMIC, 470PF,PORM 20 PCT, 100V SINGER PART NO. 556147-002	390-000-X5U0471M	72982	1
A8C5	CAPACITOR,VARIABLE, 0.8 TO 4.5 PF SINGER PART NO. 556147-001	560-013	72982	1
A8FL1 THRU FL3	SAME AS A2FL1			
A8J1	SAME AS A2J2			
A8J2	SAME AS A5J1			
A8L1	COIL,RF	132-0283-001	16665	1
A8Q1	TRANSISTOR SINGER PART NO. 556147-003	2N4427	02735	1
A8R1	RESISTOR FIXED,COMP., 240 OHMS,PORM 5 PCT 1W SINGER PART NC. 151-1004-241J	GB2415	01121	U
A8R2	RESISTOR FIXED,PREC., 292.4 OHMS,PORM 1 PCT, 1/10W SINGER PART NO. 556204-024	DC1/10-292.4 1PCT-NH	91637	1
A8R3	1/10W SINGER PART NO. 556204-003	DC1/10-17.6 1PCT-NH	91637	1
A8R4	SAME AS A8R2			
A8R5	RESISTOR,TEMPERATURE,SENSITIVE, 3.3K,PORM 10 PCT SINGER PART NO. 556147-011	TM1/4,3.3K	01295	1
A8T1	TRNASFORMER, 50 TO 12.5 OHMS	132-0277-001	16665	1
A8T2	TRANSFORMER, 200 TO 50 OHMS	132-0278-001	16665	1
A8T3	TRANSFORMER 50 TO 12.5 OHMS	132-0282-001	16665	1
A9	TRIPLER OSCILLATOR ASSY	103-1580-001	16665	1
A9FL1 AND FL2	SAME AS A2FL1			
A9J1	CONNECTOR,JACK SINGER PART NO. 556146-968	6022	91737	1
A9A1	OSCILLATOR ASSY	103-1573-001	16665	1
A9A1C1	CAPACITOR FIXED,DIPPED MICA, 20PF PORM 5PCT 500V SINGER PART NO. 150-2002-200EJ0	DM15E200J0500WV4CR	72136	1
A9A1C3	CAPACITOR,FIXED,CERAMIC DISC, 470PF,1000V SINGER PART NO. 556146-695	DD471	71590	1
A9A1C4	CAPACITOR,VARIABLE, 2 TO 8 PF SINGER OART NO. 150-0008-001	538-011A2-8	72982	1
A9A1C5	CAPACITOR,FIXED,DIPPED MICA, 15 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-150EJ0	DM15E150J0500WV4CR	72136	1
A9A1C6	SAME AS A9A1C3			
A9A1C7	CAPACITOR,FIXED,DIPPED MICA, 39 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-390EJ0	DM15E390J0500WV4CR	72136	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A9A1C8	SAME AS A2C1			
A9A1C9	CAPACITOR,VARIABLE, 9 TO 35 PF SINGER PART NO. 150-0008-008	538-01109-35	72982	1
A9A1C10	SAME AS A9A1C3			
A9A1L2	SAME AS A5L1			
A9A1Q1	TRANSISTOR SINGER PART NO. 556146-251	2N3563	INSTD	1
A9A1Q2	TRANSISTOR SINGER PART NO. 556146-702	2N3642	79089	
A9A1R1	RESISTOR FIXED,COMP., 430 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-431J	CB4315	01121	1
A9A1R2	RESISTOR FIXED,COMP., 620 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-621J	CB6215	01121	1
A9A1R5	SAME AS A9A1R2			
A9A1R6	RESISTOR FIXED,COMP., 510 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-511J	CB5115	01121	1
A9A1TP1	TEST POINT SINGER PART NO. 556205-001	51-051-0000	98291	1
A9A1T1	TRANSFORMER	132-0257-001	16665	1
A9A1T2	TRANSFORMER,VARIABLE	132-0256-001	16665	1
A9A1Y1	CRYSTAL,104.167	556146-693	16665	1
A9A2	TRIPLER ASSY	103-1572-001	16665	1
A9A2C1	CAPACITOR,VARIABLE, 2.5 TO 11 PF SINGER PART NO. 150-0008-003	538-01182.5-11	72982	1
A9A2C2	CAPACITOR,FIXED,DIPPED MICA, 56 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-560EJ0	DM15E560J0500WV4CR	72136	
A9A2C3	CAPACITOR,FIXED,FEED-THRU, 1000 PF,PORM 20 PCT,500V SINGER PART NO. 556146-746	2404-000-X500-102P	72982	1
A9A2C4	SAME AS A2C1			
A9A2C5	SAME AS A2C1			
A9A2C6	SAME AS A9A2C3			
A9A2C7	CAPACITOR,FIXED,DIPPED MICA, 18 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-180EJ0	DM15E180J0500WV4CR	72136	1
A9A2C8	CAPACITOR,FIXED,DIPPED MICA, 2 PF,PORM 5 PCT 500V SINGER PART NO. 150-2002-2R0EJ0	DM15E2R0J0500WV4CR	72136	1
A9A2C9	CAPACITOR,FIXED,DIPPED MICA, 33 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-330EJ0	DM15E330J0500WV4CR	72136	1
A9A2L1	INDUCTOR	132-0264-001	16665	1
A9A2L2 AND L3	INDUCTOR,SHIELDED, 0.56 UH SINGER PART NO. 556200-003	DINK 0.56	78526	1
A9A2L4	INDUCTOR,VARIABLE	132-0259-001	16665	1
A9A2L5	INDUCTOR,VARIABLE	132-0258-001	16665	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A9A2L6	INDUCTOR	132-0263-001	16665	1
A9A2Q1	TRANSISTOR SINGER PART NO 556146-679	2N3866	79089	1
A9A2R1	RESISTOR FIXED,COMP., 150 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-151J	CB1515	01121	1
A9A2R2	RESISTOR FIXED,COMP., 2.7 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-2R7J	CB2R75	01121	1
A9A2R3	RESISTOR FIXED,PREC., 11.61 OHMS,PORM 1 PCT, 1/10W SINGER PART NO. 556204-002	DC1/10-11.61 1PCT-NH	91637	1
A9A2R4	RESISTOR FIXED,PREC., 105 OHMS,PORM 1 PCT, 1/10W SUNGER PART NO. 556204-017	DC1/10-105 1PCT-NH	91637	1
A9A2R5	SAME AS A9A2R3			

INSTRUCTION MANUAL

Panoramic*

MAIN FRAME

MODEL MF-100

Instruction Manual No. 110-5079

Serial No. _____

SINGER
INSTRUMENTATION

Precision electrical and electronic instruments for measurement

emc — EMPIRE* — Gertsch* — Panoramic* — Sensitive Research*

THE SINGER COMPANY • METRICS DIVISION

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ADDENDUM

for

MODEL MF-100

(Effective on equipment serial numbered U30730 and up.)

I. PURPOSE.

To improve equipment operation.

II. ADDENDUM.

a. In figure 5-5, change the value of L5 from 1uH to 0.68uH.

b. In figure 5-17, add R113 (51 ohms) between the emitter of Q30 and the junction of R78 and terminal 7.

c. In table 6-2, incorporate the following entries:

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A3L4 and L5	COIL, RF, 0.68UH SINGER P/N 556012-013	CLA-0.68PORM 10 PCT	75042	1
A5R113	SAME AS R50			

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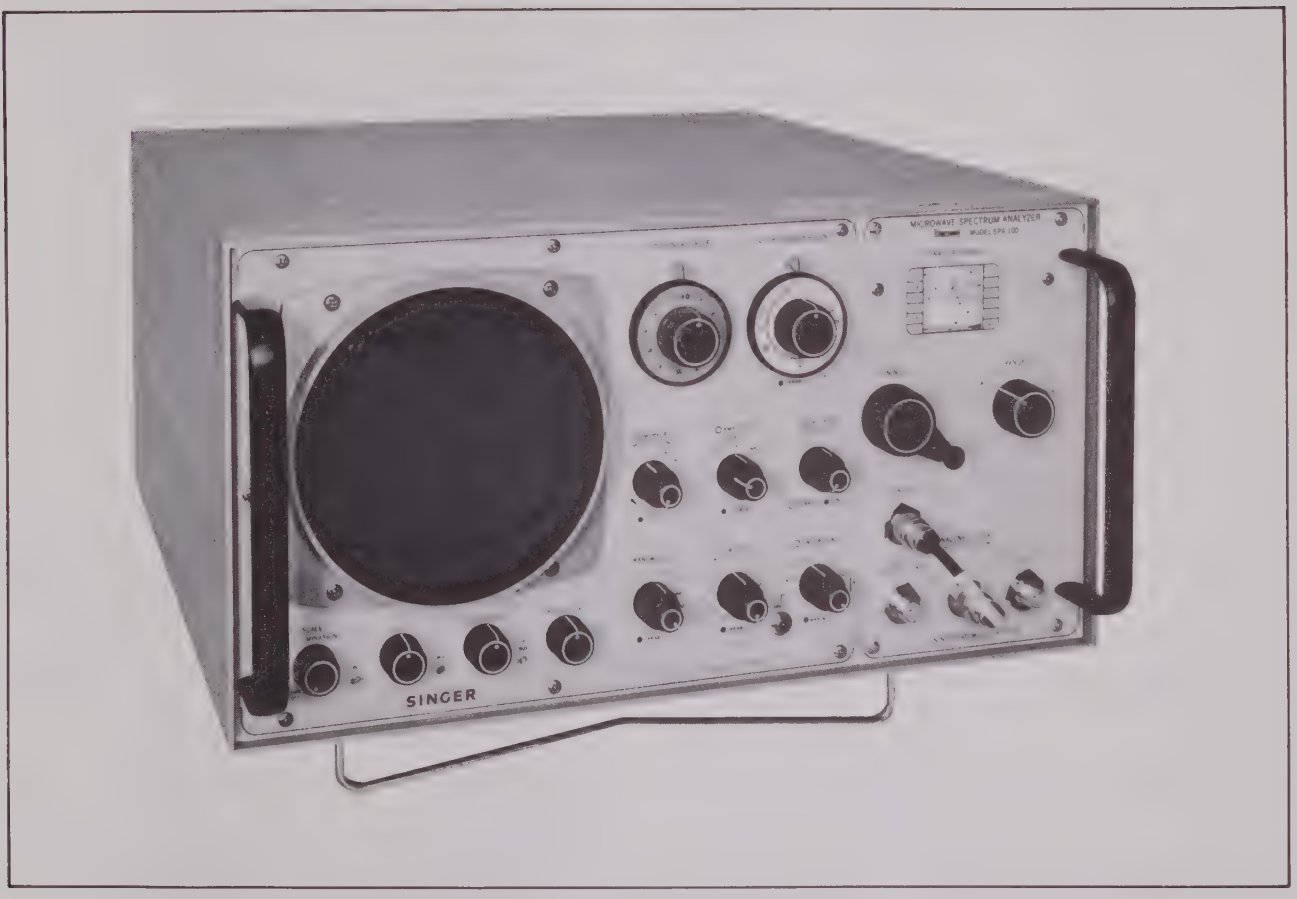

Figure 1-1. Model MF-100 Main Frame with
Model RF-100 Tuning Head Installed

SECTION I
INTRODUCTION

1-1. SCOPE OF MANUAL.

1-2. This manual provides general information, theory of operation and maintenance instructions for the Model MF-100 Main Frame portion (see figure 1-1) of the PANORAMIC* Model SPA-100, SPA-100A and SPA-3000 Microwave Spectrum Analyzers, manufactured by The Singer Company - Metrics Division.

Note

The operating instructions for the Model MF-100 Main Frame is incorporated into the operating instructions of the applicable Tuning Head (Model RF-100, RF-100A or RF-3000) which constitutes the particular microwave spectrum analyzer system. These instructions are contained in the appropriate manual within the front half of this volume.

1-3. The information contained in this handbook reflects the standard Model MF-100 Main Frame (hereafter referred to as the Main Frame) and is current only to the date of publication. Differences in equipment configuration, components, specifications and performance resulting from customer application requirements and/or The Singer Company's continuous product improvement program are described in addendum sheets.

1-4. PURPOSE AND USE OF THE EQUIPMENT.

1-5. The Main Frame is the display section of the spectrum analyzer. When used in conjunction with associated Tuning Heads, the Main Frame enables the user to visually examine the amplitude-frequency characteristics of applied signals (spectrum analyzer mode of operation) as well as the amplitude-time characteristics (synchroscope mode of operation).

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1-6. The wide variety of calibrated amplitude scales, i-f bandwidths, dispersions, sweep speeds and attenuators plus the selectable synchronization capabilities makes the spectrum analyzer an invaluable tool in the analysis of r-f signals. Some typical applications of the equipment are listed below.

a. Nanosecond pulse analysis.

b. CW, AM, FM, pulse and random noise analysis.

c. Accurate modulation index and deviation measurement of frequency-modulated signals.

d. Intermodulation distortion measurements.

e. Stability measurements of r-f sources.

f. Simplified tuning of frequency multipliers.

g. RFI and EMC spectrum monitoring.

h. Measuring close-in spurious and noise of r-f sources.

1-7. SPECIFICATIONS.

1-8. The electrical and physical specifications of the Main Frame (independent of associated Tuning Heads) are listed in table 1-1.

1-9. ELECTRON TUBE, TRANSISTOR, DIODE AND FUSE COMPLEMENT.

1-10. The types and functions of the entire complement of electron tubes, transistors and diodes employed in the Main Frame are listed in table 1-2; the fuse complement is listed in table 1-3.

TABLE 1-1. SPECIFICATIONS

Parameter	Specification
Signal input	100-MHz band of frequencies centered at 160 MHz
Input impedance	50 ohms
Display dispersion:	
Range	Seven calibrated steps from 10 kHz to 100 MHz in 1-3-10 sequence, continuously adjustable between steps; zero-dispersion capability for receiver or synchroscope operation
Accuracy	±5%

TABLE 1-1. SPECIFICATIONS (Cont'd)

Parameter	Specification
Markers (auto calibration):	
Internal	160-MHz center frequency marker either alone or with selectable 1- and 10-MHz sideband modulation capability
External	1-kHz to 1-MHz sideband modulation capability of internal 160-MHz center frequency marker
Signal attenuation:	
Range	0 to 69 dB in 1-dB steps
Accuracy	±0.05 dB/dB
Intermediate frequencies	60 and 6.5 MHz
Bandwidths:	
Fixed	Six calibrated steps of 1 kHz, 3 kHz, 10 kHz, 30 kHz, 100 kHz, 1MHz and AUTO (automatically selects bandwidth for optimum CW resolution)
Variable	1 to 100 kHz, continuously adjustable
Video filter	Tracked with variable bandwidth, independently adjustable in calibrated bandwidth step positions
Variable i-f gain	20 dB (minimum)
Amplitude scales:	
Logarithmic	60 dB (on screen); accuracy ±2 dB
Linear	Relative voltage; accuracy ±3% of full scale
Power (square law)	Relative power; accuracy ±5% of full scale
CRT	5ADP31M
Graticule	7.5 cm high x 10 cm wide
Sweep modes	Internal, external, manual or single sweep
External sweep input	-5 to +5 volts for full sweep
Sweep time	Eleven calibrated steps from 10 usec/ division to 1 second/ division in 1-3-10 sequence, continuously adjustable between steps; vernier extends slowest time to at least 3 seconds/ division
Spectrum analyzer mode	3 milliseconds/division to 1 second/division
Synchroscope mode	10 usec/division to 1 millisecond/division
Synchronization	Free-running, line, internal or external
External sync level	+3 volts (minimum)
Intensifier	Baseline clipper for brighter display of narrow pulses

TABLE 1-1. SPECIFICATIONS (Cont'd)

Parameter	Specification
Auxiliary outputs:	
Vertical output	0 to +1 volt (nominal); source impedance 1000 ohms
Horizontal output	-0.5 to +0.5 volts (nominal); source impedance 1000 ohms
Predetected 60 MHz output	5-MHz bandwidth
Power requirements	115 or 230 vac (±10%), 47 to 440 Hz, 70 watts
Size (rack mount)	16-3/4" wide x 8-23/32" high x 19-1/2" deep
Weight	50 pounds

TABLE 1-2. ELECTRON TUBE, TRANSISTOR AND CRYSTAL DIODE COMPLEMENT

Reference Symbol Number	Electron Tube, Transistor or Diode Type	Function
Main Chassis		
CR1	1N821	Clipper
Q1	2N3613	Series regulator
Q2 and Q3	2N3613	D-c amplifiers
Q4	2N3613	Series regulator
Q5	MJ2252 (Motorola)	Series regulator
V1	5ADP31M	CRT
Marker Oscillator A2A1		
CR1 through CR4	1N34A	Balanced mixer
Q1	2N3563	160-MHz oscillator
Q2	2N3563	Amplifier
Q3	2N3563	10-MHz oscillator
Q4	2N3565	1-MHz oscillator
Marker Level A2A2		
CR1 and CR2	FDH666 (Fairchild)	Variable attenuator
160-MHz Wideband Amplifier A2A3		
Q1 through Q3	S24058 (Fairchild)	160-MHz amplifiers
Q4	S24058 (Fairchild)	Emitter follower

TABLE 1-2. ELECTRON TUBE, TRANSISTOR AND CRYSTAL DIODE COMPLEMENT (Cont'd)

Reference Symbol Number	Electron Tube, Transistor or Diode Type	Function
Swept Oscillator A2A7		
CR1 through CR4	1N82AG	Balanced mixer
CR5	FDH666 (Fairchild)	Clamp
CR6	1N942A	Voltage regulator
Q1	2N3642	Adder
Q2	132-0317-001 (Singer-Metrics)	Shaping amplifier
Q3	2N3563	Wideband swept oscillator
Q4	2N3932	60-MHz amplifier
Q5	2N3563	Narrowband swept oscillator
Q6	SE7010 (Fairchild)	Shaping amplifier
Q7	2N3565	Adder
60-MHz I-f Amplifier A2A8		
Q1 and Q2	2N3563	60-MHz amplifiers
Q3	SE5001 (Fairchild)	60-MHz amplifier
Q4	2N3563	60-MHz amplifier
60-MHz to 6.5-MHz Converter A2A9		
Q1	2N3563	53.5-MHz oscillator
Q2	2N3563	Mixer
6.5-MHz Wideband Filter A3A1		
CR1 through CR4	1N251	Diode switches
Q1	2N3563	6.5-MHz amplifier
6.5-MHz Narrowband Filter A3A2		
Q1	2N3694	6.5-MHz amplifier
Q2	2N3694	Emitter follower

TABLE 1-2. ELECTRON TUBE, TRANSISTOR AND CRYSTAL DIODE COMPLEMENT (Cont'd)

Reference Symbol Number	Electron Tube, Transistor or Diode Type	Function
6.5-MHz Variable Bandwidth I-f Amplifier A3A3		
CR1 through CR4	1N251	Diode switches
Q1	2N3694	6.5-MHz amplifier
Q2	2N3015	Emitter follower
Q3	2N3015	Paraphase amplifier
Q4	2N3694	Emitter follower
Q5	2N3694	6.5-MHz amplifier
Q6	2N3694	Paraphase amplifier
Q7	2N3694	P/O Darlington emitter follower
Q8	2N3642	P/O Darlington emitter follower
6.5-MHz Logarithmic Amplifier A3A4		
CR1 through CR6	1N251	Video detectors
Q1	SE3002 (Fairchild)	6.5-MHz limiting amplifier
Q2 and Q3	2N3646	6.5-MHz limiting amplifiers
Q4	2N3694	Emitter follower
Q5 through Q7	2N3646	6.5-MHz limiting amplifiers
Q8	2N3568	P/O Complementary amplifier
Q9	2N3638	P/O Complementary amplifier
Linear/Power Amplifier A3A5		
CR1	FDH666 (Fairchild)	Video detector
CR2	1N749	Coupling diode
Q1	2N3641	6.5-MHz amplifier
Q2	2N3568	P/O Complementary amplifier
Q3	2N3638	P/O Complementary amplifier
Q4	2N3638	Emitter follower
Q5	U148 (Siliconics)	Square-law amplifier

TABLE 1-2. ELECTRON TUBE, TRANSISTOR AND CRYSTAL DIODE COMPLEMENT (Cont'd)

Reference Symbol Number	Electron Tube, Transistor or Diode Type	Function
Linear/Power Amplifier A3A5 (Cont'd)		
Q6	2N3568	P/O Complementary amplifier
Q7	2N3638	P/O Complementary amplifier
Deflection Amplifiers A4		
Q1 and Q2	2N3694	Emitter-coupled difference amplifier
Q3	2N3638	Amplifier
Q4 and Q5	2N3694	Emitter-coupled difference amplifier
Q6	2N3638	Amplifier
Q7	2N3641	Constant current source
Q8 and Q9	2N3440	Vertical deflection amplifier
Q10	2N3641	Constant current source
Q11 and Q12	2N3440	Horizontal deflection amplifier
Sawtooth/Intensifier A5		
CR1 and CR2	FDH666 (Fairchild)	Clamps
CR3	FDH666 (Fairchild)	Switch
CR4	1N749	Voltage regulator
CR5 and CR6	FDH666 (Fairchild)	Clamps
Q2	2N3694	P/O Emitter-coupled difference amplifier
Q3	2N3641	P/O Emitter-coupled difference ampl.
Q4 and Q5	2N3646	Schmitt trigger
Q6	2N3638	Pulse amplifier
Q7	2N3641	P/O Emitter-coupled difference amplifier
Q8	2N3440	P/O Emitter-coupled difference ampl.
Q9	2N3440	Driver emitter follower
Q10	2N3646	Emitter follower

TABLE 1-2. ELECTRON TUBE, TRANSISTOR AND CRYSTAL DIODE COMPLEMENT (Cont'd)

Reference Symbol Number	Electron Tube, Transistor or Diode Type	Function
Sawtooth/Intensifier A5 (Cont'd)		
Q11 and Q12	2N3646	Bistable multivibrator
Q13	2N3638	Biasing transistor
Q14	2N3638	P/O Discharge network
Q15	2N1480	P/O Discharge network
Q16	2N2945	Constant current source
Q17	2N3638	P/O Biasing network
Q18	2N3641	P/O Biasing network
Q19 through Q23	2N3646	NOR Gates
Q24 through Q26	2N3646	Inverters
Q27 and Q28	2N3646	NOR Gates
Q29	2N3646	P/O Darlington emitter follower
Q30	2N5306	P/O Darlington emitter follower
Q31 and Q32	2N3646	Schmitt trigger
Q33	2N3646	Inverter
Q34 and Q35	2N5306	Emitter-coupled Darlington difference amplifier
Q36 and Q37	2N3646	Schmitt trigger
Q38 and Q39	2N3646	Monostable multivibrator
Q40	2N3638	Timing switch
CRT Power Supply A6		
CR1	1N251	Discharge diode
CR2 and CR3	1N251	Back-bias protective diode
CR4 through CR9	EH-300 (Electronic Divices)	Voltage doublers
Q1 and Q2	2N4922	Oscillator
Q3	2N4870	Starting transistor

TABLE 1-2. ELECTRON TUBE, TRANSISTOR AND CRYSTAL DIODE COMPLEMENT (Cont'd)

Reference Symbol Number	Electron Tube, Transistor or Diode Type	Function
Rectifier/Filter A7		
CR1 and CR2	MV-10C (Solitron)	Full-wave rectifier
CR3 and CR4	1N4089	Full-wave rectifier
CR5 through CR8; CR9 through CR12	1N4089	Full-wave bridge rectifiers
Power Supply Control A8		
CR1 and CR2	1N4089	Short circuit protection
CR3	1N821	Voltage regulator
CR4 and CR5	1N4089	Short circuit protection
CR6	1N821	Voltage regulator
Q1	2N3440	Emitter follower
Q2	2N3440	D-c amplifier
Q3 and Q4	2N3440	Emitter-coupled difference amplifier
Q5	2N3638	Emitter follower
Q6 and Q7	2N3694	D-c amplifiers
Q8	2N3638	Emitter follower
Q9 and Q10	2N3694	D-c amplifiers
V1	Z82R (Signalite)	Voltage regulator
Auxiliary Control A9		
Q1	2N3641	P/O Emitter-coupled difference amplifier
Q2	2N3563	Constant current source
Q3 and Q4	2N3638	Darlington emitter follower
Q5 and Q6	2N3641	P/O Emitter-coupled difference amplifier
Q7 and Q8	2N3638	Darlington emitter follower
Q9	2N3563	Constant current source
Q10	2N3641	P/O Emitter-coupled difference amplifier

TABLE 1-3 FUSE COMPLEMENT

Reference Symbol Number	Type	Function
F1 and F2	1.25 ampere (delay)	Line protective fuses
A7F1	0.1 ampere (delay)	+100 volt supply protective fuse
A7F2	2 ampere (delay)	+12 volt supply protective fuse
A7F3	1.25 ampere (delay)	-12 volt supply protective fuse

SECTION II
OPERATION

2-1. GENERAL.

2-2. The procedures for proper operation of the Main Frame are dependent upon the associated Tuning Head that constitutes the spectrum analyzer system. The operating procedures for the particular system are therefore contained in the Operation section of the appropriate Tuning Head manual (volume which occupies the front half of this volume).

SECTION III
THEORY OF OPERATION

3-1. GENERAL.

3-2. The Main Frame, used in conjunction with an appropriate Tuning Head, displays the frequency-energy distribution of a signal or group of signals within the range of the tuning head. The Main Frame is basically a double-conversion superheterodyne receiver which is automatically and repetitively tuned through a portion of the frequency band (the portion is selected at the tuning head), with the output displayed as vertical deflections on a CRT screen. Because the horizontal sweep of the CRT is synchronized to the frequency of the swept local oscillator of the Main Frame, the vertical deflections are automatically positioned along the frequency-calibrated horizontal axis of the CRT screen.

3-3. SIMPLIFIED BLOCK DIAGRAM ANALYSIS.

3-4. The simplified block diagram, figure 3-1, shows the functional relationship of all circuits in the MF-100. All front panel controls, indicators, and connectors are included in the diagram.

3-5. The input signal from the tuning head, applied at the IF INPUT connector at the rear of the Main Frame, occupies the frequency band of 160 ± 50 MHz. This signal is applied through an input i-f attenuator that can be adjusted with the IF ATTENUATOR controls in 1 dB steps from 0 to 69 dB to prevent overloading the circuits of the Main Frame. The attenuated signal is applied to a 160 MHz amplifier where it is combined with the output of the marker generation circuits. The output of the marker generation circuits consists of a 160 MHz carrier (except when the MARKER MODULATION LEVEL control is rotated fully ccw to OFF) with or without modulation sidebands. The modulation may be produced by an internally generated 10 MHz signal, which produces sidebands at 10 MHz intervals, or by an internally generated 1 MHz signal, producing sidebands at 1 MHz intervals, or from an external source producing sidebands at any desired frequency spacing. The source of modulation is controlled by the MARKER MODULATION switch. The amplitude of the marker output is controlled by the MARKER MODULATION LEVEL control.

3-6. The output of the 160 MHz amplifier is applied through high-pass and low-pass filters to a mixer where it is mixed with the output of the swept local oscillator. The high- and low-pass filters prevent the generation of spurious responses, that would otherwise result from mixing extraneous outputs from the 160 MHz amplifier and harmonics of the swept local oscillator. The wideband swept local oscillator operates above the incoming i-f signal while the narrow band swept local oscillator operates below the incoming i-f signal. The selected local oscillator is swept above and below its center frequency (220 MHz or 100 MHz) by the sawtooth sweep input from the sawtooth generation circuits. The range over which the selected local oscillator is swept is determined by the setting of the FREQ DISPERSION switch and VARIABLE control; at maximum frequency dispersion, the wideband local oscillator is swept from 270 to 170 MHz, producing a frequency sweep of 100 MHz. At .3 MHz/DIV, which is the maximum dispersion for the narrow band local oscillator, the oscillator is swept from 101.5 to 98.5 MHz, producing a frequency sweep of 3 MHz. The center frequency of the selected local oscillator is adjusted by the SIGNAL FREQ POSITION controls. Because the local oscillator in the tuning head operates above the incoming signal, lower frequency inputs produce higher difference frequencies; by sweeping the swept local oscillator from its higher frequency to its lower frequency, the higher difference frequency inputs to the Main Frame produce 60 MHz outputs from the mixer earlier in the sweep so that the frequency scale on the CRT is read from left to right. A discrete frequency input such as a CW input or a marker input, combines with the swept local oscillator output to produce, for a finite time during the sweep, a continuously varying difference frequency that will pass through the 60 MHz i-f amplifiers (the difference frequency, during this finite time, will change continuously from one end of the i-f bandpass to the opposite end). The i-f output of the mixer is applied through a 60-MHz amplifier to two other 60-MHz amplifiers. One of these amplifiers provides the 60-MHz output at the rear panel of the Main Frame; this output has a bandwidth of 5 MHz. This broadband output permits the unit to be used as a standard receiver. The gain of the other i-f amplifier is continuously adjustable over a 20-dB range by the front panel IF GAIN control. This uncalibrated control sets the pip amplitude to a convenient height for relative amplitude measurements. The output of this 60-MHz amplifier is applied to a mixer where it is combined with the fixed frequency output of the 53.5-MHz crystal oscillator. The 6.5-MHz output of this mixer is applied to the first of two diode switches.

3-7. The diode switch is controlled by the bandwidth control circuits so that the 6.5 MHz signal is routed to the 6.5 MHz wideband amplifier when the BANDWIDTH switch is set at 1000 kHz, while in other positions, the diode switch applies the 6.5 MHz signal to the narrow-band filter and then to a variable bandwidth amplifier. The variable bandwidth amplifier is controlled by the bandwidth control

circuits to provide a bandwidth of 1, 3, 10, 30, or 100 kHz. When the BANDWIDTH control is set to VAR, the BANDWIDTH VARIABLE control provides uncalibrated continuous adjustment of the bandwidth between the limits of 1 and 100 kHz. The output of either the wideband amplifier or the variable bandwidth amplifier is selected by a second diode switch that is controlled in the same manner as the first diode switch. The output of the second diode switch is applied to the log amplifier. The log amplifier provides two outputs. One output is derived from a log shaping circuit within the log amplifier; this output is a video signal whose amplitude is proportional to the log of the input amplitude. The other output of the log amplifier is applied through a 6.5 MHz amplifier and a linear detector to both a linear amplifier and a square law amplifier whose output, proportional to the square of the input amplitude, represents the relative power of each of the displayed frequency components. The desired amplitude-adjusted signal is selected by the AMPLITUDE SCALE switch and applied through the video amplifier and vertical deflection amplifier to the vertical deflection plates of the CRT. Continuous control of the video filter is provided by the BANDWIDTH VARIABLE control in all positions of the BANDWIDTH switch, except in the 1000 kHz position; in this position, there is no video filtering. With the switch in the VAR position, the BANDWIDTH VARIABLE control simultaneously affects the video filtering and i-f bandwidth so that the video bandwidth is automatically tracked with the i-f bandwidth.

3-8. The sawtooth that produces the horizontal sweep on the CRT and simultaneously sweeps the swept local oscillator circuits is generated in the sawtooth generation circuitry. When the SWEEP switch is set to any of the MS/DIV positions, the sawtooth generation circuits are set for analyzer operation and the sawtooth generation circuits may be either synchronized or free-running. In addition, when the SWEEP/SYNC switch is set to EXT SWEEP, an external sweep input may be used in lieu of the internally generated sawtooth; this permits the spectrum analyzer to be controlled (programmed) from a remote source. When the SWEEP switch is set to any of the US/DIV positions, the sawtooth generation circuits are set for synchroscope operation. In addition to generating the sawtooth, the sawtooth generation circuits produce a blanking signal that blanks the CRT between successive traces. The blanking pulse from the sawtooth generation circuits is applied through the intensifier circuits to the control grid of the CRT. Video pulses from the video amplifier are also applied to the intensifier circuits and, when their amplitude exceeds the voltage established by the INTENSIFIER control, produce intensification on the CRT that is controlled by the BRIGHTNESS control.

3-9. DETAILED THEORY OF OPERATION

3-10. GENERAL. The detailed theory of operation, given in paragraphs 3-11 on, is subdivided into seven parts, in which the individual functions are described. These descritpions are based on the detailed block diagrams and simplified schematics contained in this section, and on the individual schematic diagrams, figures 5-1 through 5-20.

3-11. SIGNAL PATH. The i-f input from the tuning head occupies a frequency band centered about 160 MHz. This input signal, is applied to i-f attenuator assembly A1 (see figure 3-2). The input attenuator consists of resistive pi attenuators that can be inserted or bypassed, depending on the position of the IF ATTENUATOR switches. One of the switches selects attenuators that can insert 10 through 60 dB of attenuation in 10-dB steps; the second switch selects attenuators that can introduce 1 through 9 dB of attenuation in 1-dB steps. Thus, the two switches combine to provide an attenuation range from 0 through 69 dB in 1-dB steps.

3-12. The attenuated i-f signal is applied to 160-MHz wideband amplifier board A2A3, which is mounted in front i-f assembly A2. The applied signal and the output of the marker generation circuits (refer to paragraph 3-20) are applied to the input of 160-MHz amplifier A2A3Q1. The output of amplifier A2A3Q1 is applied to negative feedback amplifier A2A3Q2 and, because the negative feedback is applied through a parallel-tuned circuit less degeneration and therefore higher gain are obtained at the higher frequencies, for they are closer to the frequency to which the tuned circuit is adjusted. This frequency-sensitive degenerative feedback compensates for the reduced high-frequency gain of the amplifier, resulting in a flat response over the range of 160 ± 50 MHz. The output of amplifier A2A3Q2 is applied through another negative feedback amplifier A2A3Q3. The output of A2A3Q3 is applied through emitter follower A2A3Q4 to A2A4, which contains a 60 MHz trap (L2, C3, and C4) that prevents an input 60 MHz signal from being applied to the balanced mixer and 60 MHz i-f amplifier; such a signal would otherwise appear as a baseline rise. A2A4 also contains an equalizer (R4, R5, and R6, C1, and L1) that introduces 1 db less attenuation at 210 MHz than at 110 MHz to further compensate for reduced high-frequency response elsewhere in the signal path. The output of A2A4 is applied to two cascaded filters A2A5 and A2A6. These filters provide sharp cutoff at the upper limit of the bandpass of the i-f. Thus these filters define the i-f bandwidth, and prevent any extraneous signals from being applied to the balanced mixer A2A7CR1-CR4.

3-13. The swept local oscillators operate at center frequencies of 220 MHz (WB) and 100 MHz (NB), which are 60 MHz above and below, respectively, the center of the frequencies applied to the input of balanced mixer A2A7CR1-CR4. At the start of each sweep, the local oscillator frequency is above its center frequency; at this time the carrier frequency to which the tuning head is tuned will produce a difference frequency from the balanced mixer that is above the bandpass of the 60 MHz amplifiers. As the sweep input varies, the difference frequency will also vary; at the end of the sweep, the difference from the balanced mixer will be below the bandpass of the 60 MHz amplifiers. For a small but finite time during the sweep, the difference frequencies that are produced are within the bandpass of the 60 MHz

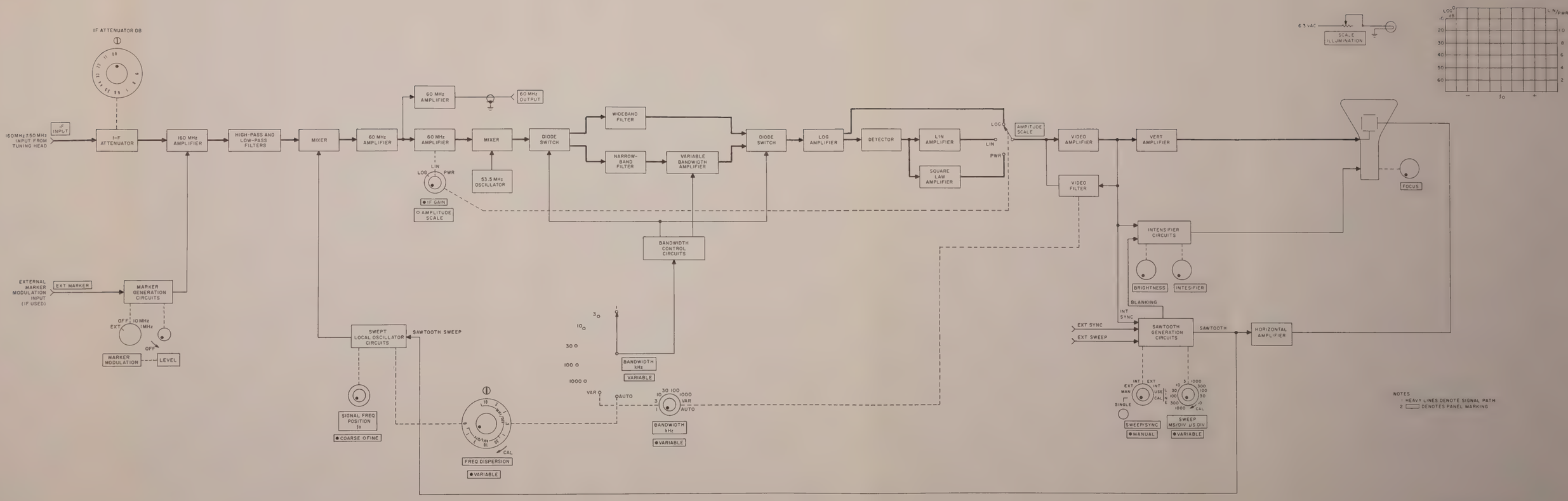
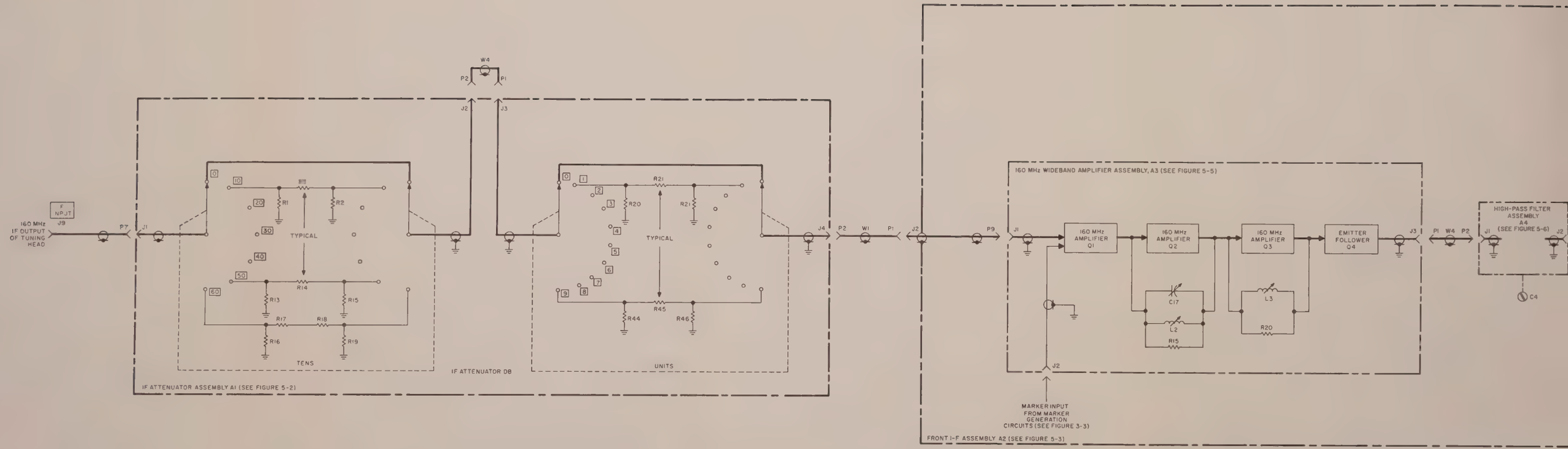


Figure 3-1. Main Frame, Simplified Block Diagram


160 MHz IF OUTPUT OF TUNING HEAD
F NP JT
J9
P7
J1
W4
P2
P1
J2
J3
0
10
20
30
40
50
60
R1
R2
TYPICAL
R13
R14
R15
R17
R18
R16
R19
TENS
IF ATTENUATOR DB
0
1
2
3
4
5
6
7
8
9
R21
R20
R21
TYPICAL
R44
R45
R46
UNITS
IF ATTENUATOR ASSEMBLY A1 (SEE FIGURE 5-2)
J4
P2
W1
P1
J2
P9
160 MHz WIDEBAND AMPLIFIER ASSEMBLY, A3 (SEE FIGURE 5-5)
J1
160 MHz AMPLIFIER Q1
160 MHz AMPLIFIER Q2
160 MHz AMPLIFIER Q3
EMITTER FOLLOWER Q4
J3
C17
L2
R15
L3
R20
J2
MARKER INPUT FROM MARKER GENERATION CIRCUITS (SEE FIGURE 3-3)
FRONT I-F ASSEMBLY A2 (SEE FIGURE 5-3)
P1
W4
P2
HIGH-PASS FILTER ASSEMBLY A4 (SEE FIGURE 5-6)
J1
J2
C4

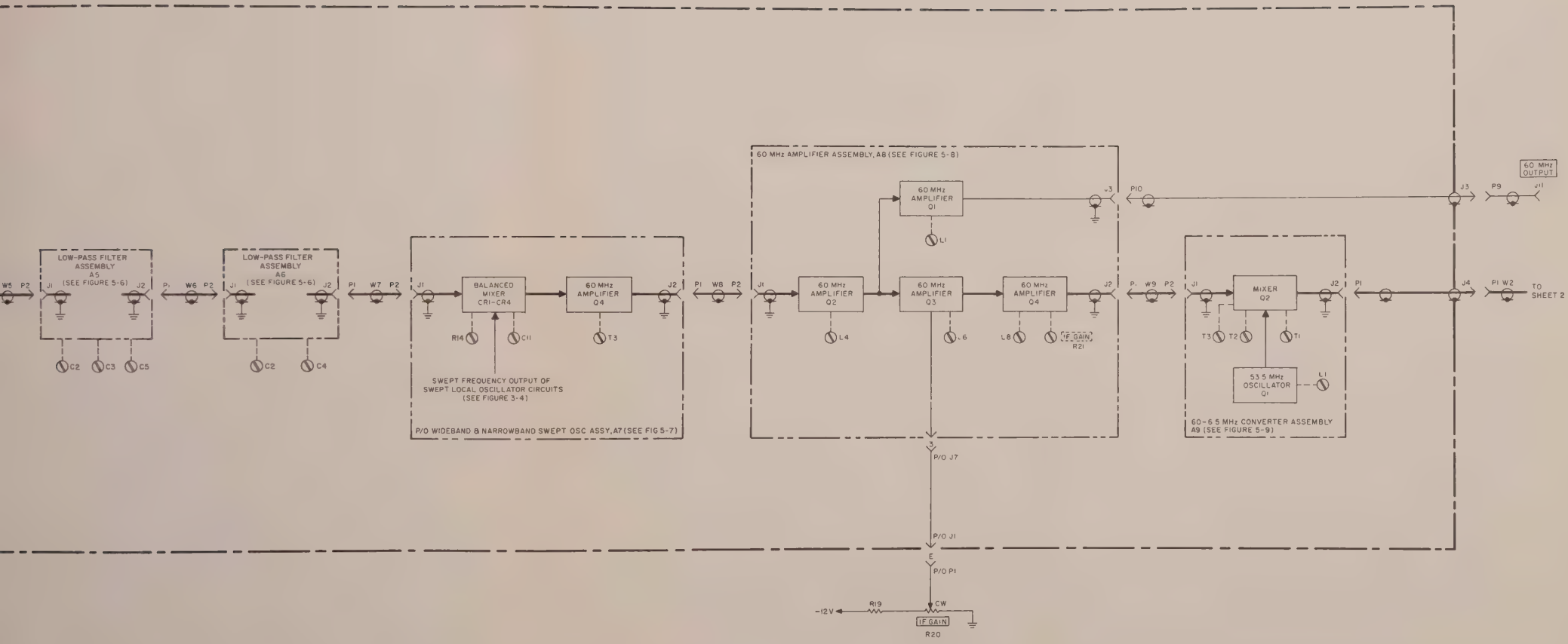
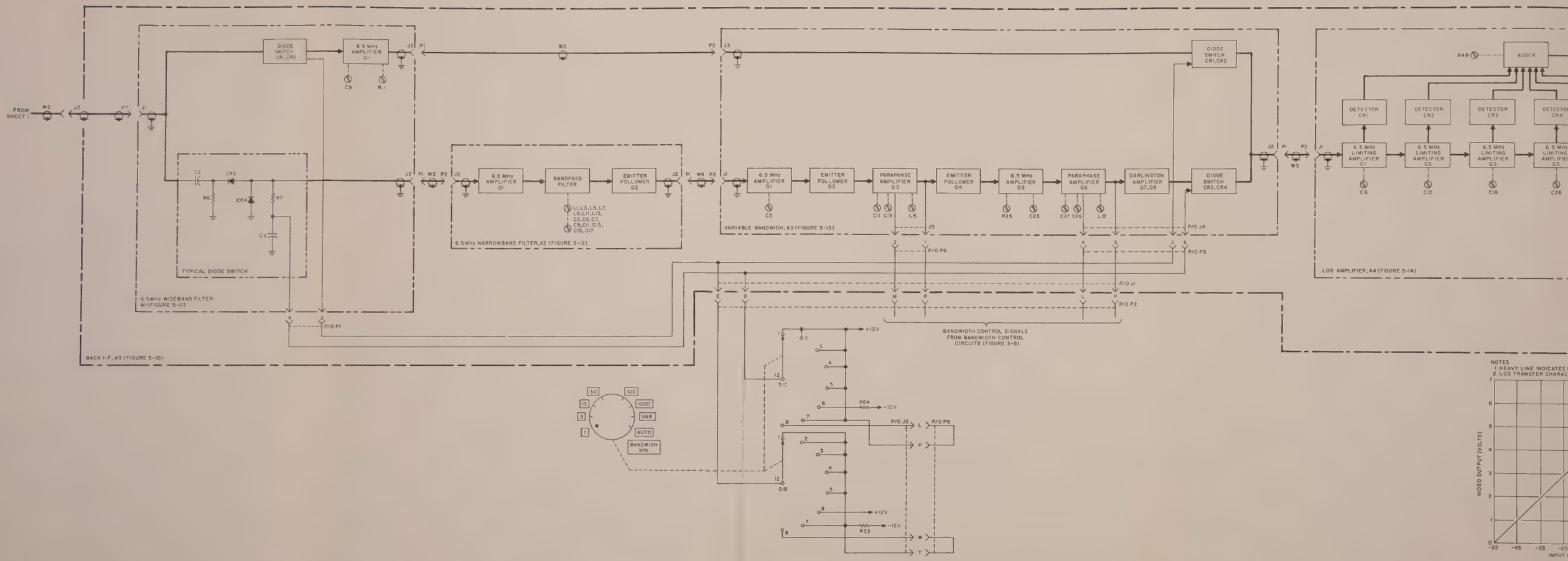


Figure 3-2. Main Frame, Detailed Block Diagram (Sheet 1 of 2)


FROM SHEET 1
W2
J2
P2
J1
DIODE SWITCH CR1, CR2
6.5 MHz AMPLIFIER Q1
J3
P1
C9
R1
W2
P2
J3
DIODE SWITCH CR1, CR2
R48
ADDER
DETECTOR CR1
DETECTOR CR2
DETECTOR CR3
DETECTOR CR4
C2
CR3
R6
CR4
R7
C4
TYPICAL DIODE SWITCH
6.5 MHz WIDEBAND FILTER A1 (FIGURE 5-11)
J2
P1
W3
P2
J2
6.5 MHz AMPLIFIER Q1
BANDPASS FILTER
EMITTER FOLLOWER Q2
L1, L3, L5, L7, L9, L11, L13, C3, C5, C7, C9, C11, C13, C15, C17
6.5 MHz NARROWBAND FILTER, A2 (FIGURE 5-12)
J2
P1
W4
P2
J1
6.5 MHz AMPLIFIER Q1
EMITTER FOLLOWER Q2
PARAPHASE AMPLIFIER Q3
EMITTER FOLLOWER Q4
6.5 MHz AMPLIFIER Q5
PARAPHASE AMPLIFIER Q6
DARLINGTON AMPLIFIER Q7, Q8
DIODE SWITCH CR3, CR4
C5
C11
C13
L5
R25
C23
C27
C26
L12
VARIABLE BANDWIDTH, A3 (FIGURE 5-13)
J5
P/O J4
J2
P1
P2
W5
J1
6.5 MHz LIMITING AMPLIFIER Q1
6.5 MHz LIMITING AMPLIFIER Q2
6.5 MHz LIMITING AMPLIFIER Q3
6.5 MHz LIMITING AMPLIFIER Q5
C6
C12
C16
C26
LOG AMPLIFIER, A4 (FIGURE 5-14)
P/O P6
P/O P3
P/O J1
P/O P2
BANDWIDTH CONTROL SIGNALS FROM BANDWIDTH CONTROL CIRCUITS (FIGURE 3-5)
P/O P1
BACK I-F, A3 (FIGURE 5-10)
+12V
S1C
R54
-12V
P/O J2
P/O P9
L
P
S1B
+12V
R53
-12V
W
T
30
100
10
1000
3
VAR
1
AUTO
BANDWIDTH kHz
NOTES
1. HEAVY LINE INDICATES
2. LOG TRANSFER CHARAC
VIDEO OUTPUT (VOLTS)
INPUT
-55
-45
-35

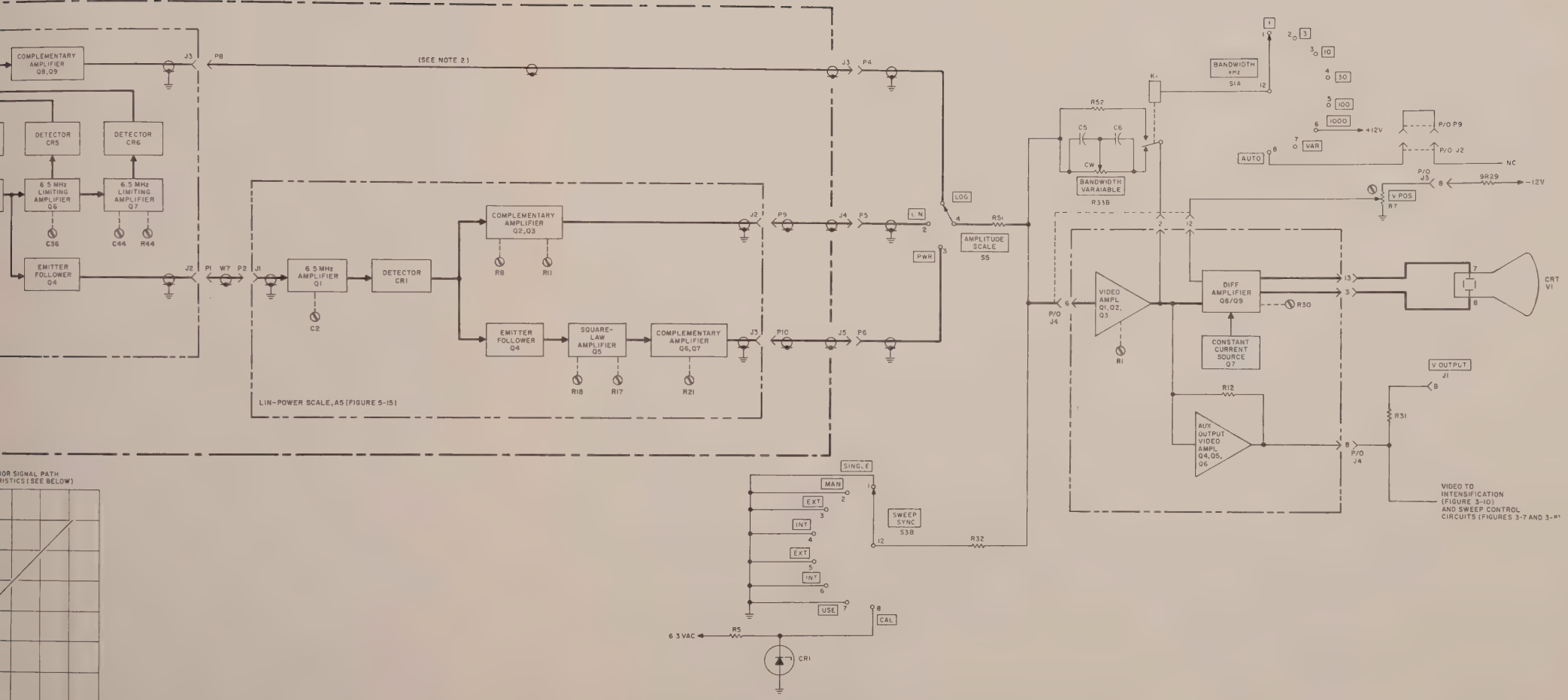


Figure 3-2. Main Frame, Detailed Block Diagram (Sheet 2 of 2)

amplifier. A separate, very stable oscillator is used as the narrow band swept local oscillator to restrict unwanted incidental FM (displacement (jitter) of frequency components on successive sweeps) due to oscillator instability. This effect is most noticeable on the lowest dispersion displays. A separate, less stable, oscillator is used as the wideband swept local oscillator to sweep over a wider range; slight instability is not noticeable at these dispersions. Both the oscillators and their sweep inputs are discussed in paragraphs 3-22 through 3-26. Potentiometer A2A7R14 primarily balances the local oscillator input to the balanced mixer, while capacitor A2A7C11 tunes the balanced mixer output to 60 MHz. However, interaction does occur and both controls are used to balance the mixer.

3-14. The output of the balanced mixer is applied through 60 MHz amplifier A2A7Q4 to 60 MHz amplifier A2A8Q2. The output of this amplifier is applied both to 60 MHz amplifier A2A8Q1 and to 60 MHz amplifier A2A8Q3. The output of A2A8Q1 which has a bandwidth of 5 MHz is applied to the 60 MHz OUTPUT connector J11 on the rear of the Main Frame. This output, when connected to appropriate detection equipment, allows the analyzers to serve as a receiver. The gain of 60 MHz amplifier A2A8Q3 is adjusted by the front panel IF GAIN control, which adjusts the negative base bias applied to this stage. The output of this amplifier is applied to 60 MHz amplifier A2A8Q4, whose gain is adjusted by internal adjustment A2A8R21; R21 is connected in series with the emitter bypass capacitor, and thereby controls degeneration. The output of A2A8Q4 is applied to mixer A2A9Q2 where it is mixed with the output of crystal oscillator A2A9Q1. The output of the mixer is at 6.5 MHz.

3-15. This 6.5 MHz output is applied to two diode switches located in 6.5 MHz WB filter A3A1 in the back i-f assembly A3. One diode switch passes the 6.5 MHz signal to 6.5 MHz amplifier A3A1Q1 when wideband i-f operation is selected, and the other diode switch passes the signal to 6.5 MHz amplifier A3A2Q1 at all other times. Each diode switch is controlled by the application of +12 or -12 volts from the BANDWIDTH switch. When -12 volts is applied to any diode switch, the series diode (such as A3A1CR3) is back-biased while the shunt diode (A3A1CR4) is shorted; under these conditions the diode switch does not pass the signal. When +12 volts is applied, the series diode is forward-biased while the shunt diode is back-biased, and the signal passes through the diode switch. Note that when the narrowband diode switches receive +12 volts, the wideband diode switches receive -12 volts.

3-16. The wideband 6.5 MHz amplifier has a 1 MHz bandwidth, while the narrow band 6.5 MHz amplifiers can be varied between 1 and 100 kHz. The gain of the amplifiers in the wideband and narrow band signal paths is separately adjustable, so that the noise level is displayed at the same amplitude in either 100 kHz or 1000 kHz bandwidth. The gain of wideband amplifier A3A1Q1 is adjusted by A3A1R11 which is the unbypassed portion of the emitter resistance. The output of A3A1Q1 is applied to a second diode switch A3A3CR1-CR4 which is controlled by the same control voltages as the first diode switch; when the first diode switch applies the 6.5 MHz signal to A3A1Q1 the second diode switch passes the output of A3A1Q1. When narrow band i-f operation is selected by the front panel BANDWIDTH switch, the output of the first diode switch is applied to A3A2Q1, which drives a sharp bandpass filter. This filter eliminates the spurious responses of the crystals in the variable bandwidth amplifier. The output of the bandpass filter is applied through emitter follower A3A2Q2 to the variable bandwidth i-f amplifier on board A3A3. The bandwidth of this amplifier is controlled continuously or in steps by dc voltages from the bandwidth control circuits (paragraph 3-27), which varies the impedance of the tuned circuit in this amplifier. The output of the paraphase amplifier is coupled from the emitter through a 6.5 MHz crystal, which is utilized in its series-resonant mode. The crystal is loaded by a paralled-tuned circuit consisting of a capacitor and A3A3L5, whose impedance determines the bandpass of the crystal (refer to paragraph 3-28). The crystal which passes the 6.5 MHz signal through the equivalent series-resonant circuit, also passes signals through its shunt capacitance. An out-of-phase signal is taken from the collector of A3A3Q3 to cancel that signal. This neutralizing signal is adjusted by capacitor A3A3C13. Capacitor A3A3C11 adjusts the phase of the signal passed through the crystal shunt capacitance so that A3A3C13 can better neutralize this signal. After processing in paraphase amplifier A3A3Q3, the signal is coupled through emitter follower A3A3Q4 and tuned amplifier A3A3Q5 to paraphase amplifier A3A3Q6, which is identical to A3A3Q3 and further controls the bandwidth. The gain of A3A3Q5 is adjusted by A3A3R25, which is a portion of the unbypassed emitter resistance of 6.5 MHz amplifier A3A3Q5. The output of the variable bandwidth amplifier is applied through diode switch A3A3CR1-CR4 to the log amplifier A3A4.

3-17. The 6.5 MHz signal from the second diode switch is applied to 6.5 MHz logarithmic i-f amplifier A3A4. This type of circuit is called successive detection. The signal is coupled to A3A4Q1, the first stage of a six-stage sequentially-limiting i-f amplifier chain. The output of each stage is applied to a diode detector A3A4CR1 through CR6, which feeds a resistive adder A3A4R8, R15, R22, R29, R40, and R47, which incorporates a delay line A3A4C7, L4, C15, L7, etc. that delays the outputs of the first stages more than those of the later ones to compensate for the inherent delay of the six-stage amplifier; thus all contributions to be added are in synchronism. Each of the six stages is identical, having the same gain and the same saturation level. As the applied signal increases above the noise the output of A3A4Q7 exceeds the threshold level of A3A3CR6, and the detector applies a voltage proportional to the input to the adder. As the signal continues to increase, the output of A3A4Q7 also increases until it reaches saturation, thereby limiting its contribution to the adder. As A3A4Q7 reaches its saturation point, the output of A3A4Q6 is of sufficient amplitude to overcome the threshold voltage of A3A4CR5, causing the diode detector to contribute to the adder. This

sequential limiting of amplification from the higher level stages and contribution of video from the lower level ones continues until the applied signal drives A3A4Q1 into saturation. Thus each successive increase of 10 db (for example) in input level produces an equal (linear) increase in output voltage. (See transfer characteristics on figure 3-2.) The adder applies the sum of the positive video contributions from detectors A3A4CR1 through CR6 to complementary amplifier A3A4Q8, Q9. The input to A3A4Q8 is adjusted by A3A4R48 so that the maximum input (sum of all contributions) corresponds to 0 dB on the LOG scale. The gain of A3A4Q7 is adjusted by A3A4R44 so that the minimum signal that produces a contribution is 60 dB below the signal level that produces saturation in A3A4Q1; thus an on-screen dynamic range of 60 dB is achieved. The complementary amplifier provides a low impedance source for driving the video amplifier (paragraph 3-19).

3-18. The output of 6.5 MHz amplifier A3A4Q5 is applied through emitter follower A3A4Q4 to the lin-power scale board A3A5. The output of A3A4Q5 is directly proportional to the input signal level until A3A4Q5 approaches saturation. The output of emitter follower A3A4Q4 is amplified by 6.5 MHz amplifier A3A5Q1 and detected by diode A3A5CR1. The detected output of A3A5CR1 is applied to complementary amplifier A3A5Q2, Q3. The complementary amplifier provides the output for the linear display on the CRT. The amplitude of the signal applied to the complementary amplifier is adjusted by screwdriver control A3A5R8. The dc voltage at the output of the complementary amplifier, which is dc coupled through the remaining circuits to the CRT, is adjusted by screwdriver adjustment A3A5R11, so that with no signal input, the CRT trace is at the baseline. The detected output of A3A5CR1 is also applied to emitter follower A3A5Q4 whose output is coupled through a Zener diode to square-law amplifier A3A5Q5. The Zener diode provides dc offset with no loss in signal amplitude. The square-law amplifier utilizes the non-linear characteristics of a field-effect transistor (FET). The gain of the square-law amplifier is established by adjusting the load resistor A3A5R18. The linearity (square-law transfer characteristic) of the amplifier is controlled by adjusting A3A5R17, thereby setting the dc gate voltage of amplifier A3A5Q5. The output of the square-law amplifier is applied through complementary amplifier A3A5Q6, Q7 whose output is dc coupled through the remaining circuits to the CRT. Baseline adjustment A3A5R21 serves the same purpose for this complementary amplifier as A3A5R11 serves for complementary amplifier A3A5Q2, Q3.

3-19. The AMPLITUDE SCALE switch selects the logarithmic output of complementary amplifier A3A4Q8, Q9, the linear output of complementary amplifier A3A5Q2, Q3, or the power output of complementary amplifier A3A5Q6, Q7. The selected output is supplied through resistor R51 to the summing junction of video amplifier A4Q1, Q2, Q3. When the SWEEP/SYNC switch S3B is set to CAL, clipped half-wave signal derived from the 6.3 vac output of the power transformer is applied through resistor R32 to the summing junction. The video amplifier consists of a difference amplifier A4Q1, Q2 and inverting amplifier A4Q3. The difference amplifier contains DC BAL adjustment A4R1, which sets the output of the amplifier to 0 VDC when no inputs are applied. In all positions of the BANDWIDTH switch except the 1000 kHz position, relay K1 is deenergized and the feedback for the video amplifier consists of the BANDWIDTH VARIABLE control R33B, which is shunted by capacitor C5 when the control is fully CCW and by C6 when the control is fully CW. The dc gain of the video amplifier is determined by the total resistance of R33B; the gain of higher frequencies depends upon the total capacitive feedback, which depends upon the setting of the BANDWIDTH VARIABLE control. When the BANDWIDTH switch is set to 1000 kHz, relay K1 is energized and the network consisting of C5, C6, and R33B is replaced by a single resistor R52, which is the same ohmic value as R33B. Thus the dc gain of the amplifier is not affected, and the video bandwidth is limited only by the amplifier. The output of the video amplifier is applied both to difference amplifier A4Q8/Q9 and to auxiliary output amplifier A4Q4, Q5, Q6. The other input to the difference amplifier is a dc voltage derived from the front panel V POS screwdriver adjustment R7. This voltage determines the dc component of the amplifier output; therefore adjusting this dc voltage shifts the display up or down without changing its amplitude. The total current through the two transistors of the differential amplifier is maintained constant by A4Q7 whose base voltage is determined by a fixed voltage divider; A4R30 adjusts the gain of the differential amplifier to provide the desired output to the CRT. The output of the auxiliary output amplifier is applied both to the V output pin J1-B, which can be used for remote operation and for X-Y plotting, and to the sawtooth trigger and intensification circuits (paragraphs 3-29 and 3-49, respectively).

3-20. MARKER GENERATION CIRCUITS. The marker generation controls can be adjusted to provide no markers, only a center frequency marker, or a center frequency marker with sidebands located at 1-MHz or 10-MHz intervals or at intervals controlled by an external modulation input. Figure 3-3 is the detailed block diagram of the marker modulation circuits. When the MARKER MODULATION LEVEL control R21 is not set to its CCW limit, switch S8, which is ganged to the MARKER MODULATION LEVEL control, applies -12 volts to the 160-MHz marker oscillator A2A1Q1 and to amplifier A2A1Q2. (See figure 3-3.) When the MARKER MODULATION switch S4 is set to OFF, the output of the 160-MHz marker oscillator is applied to balanced modulator A2A1CR1 through CR4, whose output is the incompletely suppressed oscillator (carrier) input. When S4 is set at 10 MHz, -12 volts is applied to the 10-MHz marker oscillator A2A1Q3. The output of this oscillator is applied through amplifier A2A1Q2, which serves as a buffer that applies the 10-MHz signal to the balanced modulator. The output of the modulator contains the incompletely suppressed carrier and sidebands spaced at 10 MHz intervals from the carrier.

3-21. When the MARKER MODULATION switch is set to 1 MHz, -12 volts is applied to 1-MHz marker

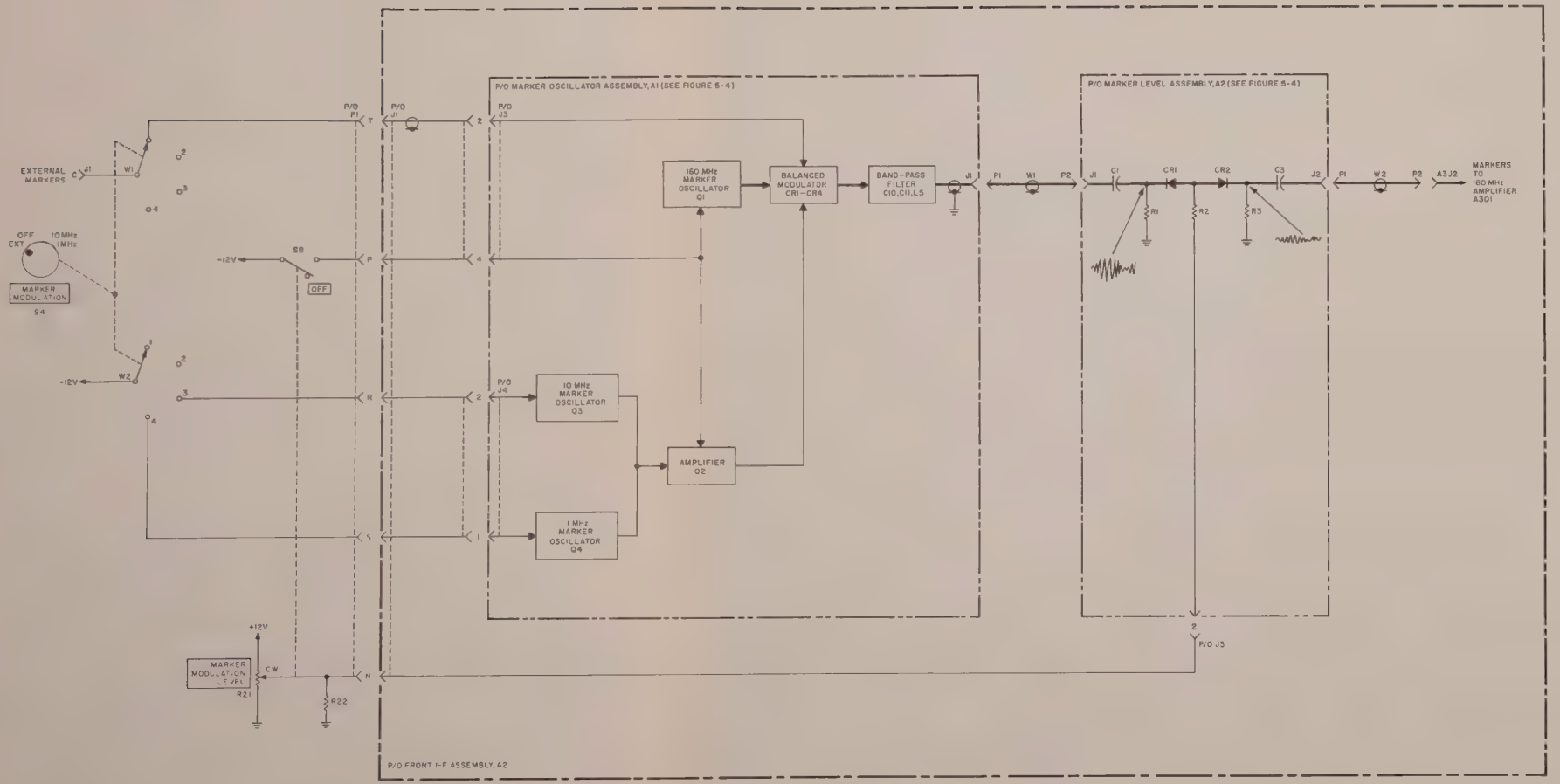


Figure 3-3. Marker Generation Circuitry, Detailed Block Diagram

oscillator A2A1Q4, and the 160-MHz carrier is then modulated by 1MHz. When the MARKER MODULATION switch is set to EXT, an external marker input, applied at pin C of connector J1, is applied directly to the balanced modulator. The modulator output is applied through bandpass filter consisting of A2A1C10, C11, and L5, which removes those frequencies that would otherwise mix with outputs of the swept local oscillators to produce spurious responses. The output of the bandpass filter is applied to marker level board A2A2. The MARKER MODULATION LEVEL control R21 establishes the forward bias on diodes A2A2CR1 and A2A2CR2, which, with A2A2R2, comprise a T-attenuator. As the forward bias increases, the impedance of the diodes decreases, and the marker output increases. The output of the marker level board is applied to the 160 MHz amplifier A3A1.

3-22. SWEPT LOCAL OSCILLATOR CIRCUITS. The swept local oscillator circuits provide the frequency to the mixer that is swept in synchronism with the CRT trace to provide the amplitude-versus-frequency display. Figure 3-4 is the detailed block diagram of the swept local oscillator circuits. The swept local oscillator circuits contain wideband local oscillator A2A2Q3 and narrow band local oscillator A2A2Q5. When FREQ DISPERSION switch S6 is set to any of the three widest-dispersion positions, +12 volts is applied through the switch contacts to the wideband local oscillator, which provides the swept local oscillator signal in these switch positions. In the remaing positions of the FREQ DISPERSION switch, +12 volts is applied to the narrow-band local oscillator, which provides the swept local oscillator signal in these switch positions. The selected local oscillator is swept by a sawtooth voltage and the resultant center frequency is determined by an applied dc voltage.

3-23. The dc voltage for the wideband local oscillator is adjusted by the front panel SIGNAL FREQ POSITION f_O COARSE and FINE controls R1A and R1B in series with screwdriver adjustments A9R20 and A9R21, respectively, and then it is applied to adder A2A7Q1. The dc voltage for the narrow-band local oscillator is controlled in the same manner, even though it is picked off from a different point in the circuit, and then applied to adder A2A7Q7.

3-24. The amplitude of the sawtooth voltage applied to the local oscillator is selected by FREQ DISPERSION switch S6 either from the voltage divider network consisting of resistors R37/R38/R39 (wideband) or R40 -- R45 (narrow band). This voltage can be adjusted by rotating FREQ DISPERSION VARIABLE control R36 counterclockwise from its CAL position. In addition, the sawtooth amplitude can be adjusted separately for each local oscillator to calibrate the various positions of the FREQ DISPERSION switch; for wideband, the sawtooth is adjusted by WB DISP screwdriver adjustment A9R17, and for narrow band by NB DISP adjustment A9R18. These sawtooth voltages are applied to adders A2A7Q1 and A2A7Q7 to combine the frequency dispersion sawtooth voltage with the signal frequency position dc voltage. When the FREQ DISPERSION switch is set at 0 (for example in synchroscope operation), the narrow-band local oscillator is energized, but no sawtooth voltage is applied. The dc voltage that is applied controls the fixed frequency at which the narrow-band local oscillator operates in this switch position.

3-25. The output of each adder, which is the sum of the dc and sawtooth inputs, is applied to a shaping amplifier A2A7Q2 or A2A7Q6. Because the local oscillators are non-linear and a linear sweep presentation is desired, the sawtooth that is applied to each shaping amplifier is reshaped to a curve that compensates for the nonlinear frequency-voltage characteristic of its associated local oscillator. Reshaping in shaping amplifier A2A7Q2 is accomplished by varistor A2A7RV1, whose resistance varies as the applied voltage changes. The overall linearity of the local oscillator output is adjusted by screwdriver adjustment A2A7R9 (wideband) and A2A7R25 (narrow band).

3-26. The wideband local oscillator A2A7Q3 is a modified Colpitts circuit in which the tuning is adjusted continuously by the current through current-controlled inductor A2A7L4. The inductance of A2A7L4 decreases as its current increases; thus the low voltage end of the sawtooth, which results in increased current through L4, produces the high-frequency limit of the local oscillator sweep. The narrow-band local oscillator is a modified Hartley circuit, which contains varactor C20, whose capacitance is a function of the instantaneous voltage applied. The output of the local oscillator that is operating is applied to the balanced mixer A2A7CR1-CR4.

3-27. BANDWIDTH CONTROL CIRCUITS. The bandwidth control circuits provide dc voltages that control the bandwidth of the 6.5 MHz variable bandwidth amplifier. Figure 3-5 is the detailed block diagram for the band-width control circuits.

3-28. The bandwidth of the 6.5 MHz variable bandwidth amplifier is controlled by the intensity of two lamps whose light outputs are played upon light-sensitive resistors; within the variable bandwidth amplifier, the bandwidth of the tuned circuits varies with these resistance values. An increase in resistance results in an increase of the bandwidth. The lamp intensity is controlled by two identical bridge circuits, each consisting of two base-bias resistance networks and a high gain difference amplifier in series with a Darlington emitter follower. Because the two control circuits are identical, only one will be discussed here. The position of BANDWIDTH switch S1D selects a resistor or combination of resistors from R46 through R49 or BANDWIDTH VARIABLE potentiometer R33A which, in series with R56 to ground, represent the control leg of the bridge. These resistors, in series with resistor A9R11 and -12V, form a voltage divider to provide base-bias for transistor A9Q5 (1/2 of the differential amplifier A9Q5/21). Base-bias for transistor A9Q1, the other half of the amplifier, is provided by the voltage divider consisting of potentiometer A9R4A to -12V, resistor A9R1 and the unknown leg of the bridge A3A3R17, which has its ground return through

A3A3L5. Changes in the setting of switch S1 (or rotation of the BANDWIDTH VARIABLE potentiometer R33A when switch S1 is set to position 7) will unbalance the bridge, causing a differential voltage between the two inputs of the differential amplifier. This differential voltage is amplified and applied to the lamp of A3A3R17, causing the light sensitive resistor to change value in such a manner as to rebalance the bridge. The variation of the light-sensitive resistance therefore is directly proportional to the change of the resistance in the control leg of the bridge. When switch S1D is set to increase the total series resistance of the control leg of the bridge, less negative voltage is developed across resistor A9R11 and the base-bias of A9Q5 becomes more negative. The amplifier output, applied to the Darlington emitter follower becomes more positive and, therefore, a smaller voltage is developed across the lamp associated with the light sensitive resistor A3A3R17. The intensity of the lamp decreases, causing the resistance of the resistor to increase. When switch S1 is set to maximum resistance, the difference amplifier is actually back-biased; the resistance of the resistor becomes very high, looking like an open circuit, and the resistance of the circuit itself determines the bandwidth. Potentiometer R4 is set to calibrate the BANDWIDTH switch.

3-29. SAWTOOTH GENERATION CIRCUITS.

3-30. General. Functionally, two circuits are employed for sawtooth generation which are not mutually exclusive: one circuit, the sweep control circuit, provides the sweep gate necessary for sawtooth generation, and a blanking gate for use in the intensification circuits; the second, a sweep generation circuit, produces the sawtooth voltage that sweeps the swept local oscillators and CRT beam. Together, these circuits form an interdependent feedback loop. The sawtooth voltage of the sawtooth generation circuit, gated by the sweep control circuit is fed back to the sweep control circuit, primarily, so that it can end the sweep gate when full-scale sweep deflection potential has been reached. Blanking takes place at this time in preparation for the next sweep.

3-31. Sweep Control Circuit. The sweep control circuit generates sweep gate and blanking pulses by alternately setting and resetting a sweep gate flip flop. The "set" state of the flip flop describes a 1 output (+12V, nominal) for the sweep gate, and a 0 output (+6V, nominal) for the blanking output. The "reset" state is just the opposite - the sweep gate output is at the 0 level while the blanking output is at the 1 level. When the flip flop is set, the sawtooth waveform of the sweep generation circuit is enabled by the 1 output from the sweep gate side of the flip flop; and, when the flip flop is reset, the CRT blanking pulse is obtained from the 1 output of the blanking side. The blanking pulse is always generated during retrace, and, whenever the beam would be stationary (if not blanked) awaiting a retrace-initiating sync pulse, under sync control in the analyzer mode.

3-32. Because retrace occurs when the output of the sweep gate flip flop changes from the set to reset state, and the blanking pulse is available only when the flip flop is in the reset state, a conflict would occur during sync operation in the analyzer mode when the blanking pulse must be generated before retrace; but, a unique flip flop is used to solve this problem.

3-33. The sweep gate flip flop is unlike most flip flops, for if both transistors receive 0 base inputs, both transistors can be cut off simultaneously; and, consequently, both outputs are true until the sweep gate is terminated by an incoming retrace generating sync pulse. In free-running operation, the flip flop changes state like any other flip flop at the end of each sweep; retrace occurs and then the flip flop changes state again to initiate a new sweep.

3-34. Biasing transistor A5Q13 (shown in figure 3-6) maintains a positive potential at the emitters of flip flop transistors A5Q11 and A5Q12 of +6V. And as a result, 1 signal inputs applied to the base of either flip flop transistor have no effect.

3-35. If the input from the flip flop driver is at the 1 state, the collector-to-base cross coupling determines the state of that transistor; if the input is a 0, however, the crosscoupling has no effect. Therefore, when 0 inputs are applied to both transistors, they can be cut off simultaneously, producing the desired similar 1 outputs.

If both inputs are at the 1 state, the flip flop remains in the state which it has previously assumed.

3-36. The sweep control circuit utilizes NOR gates (figure 3-7) as the basic logic element. Each gate employs an NPN transistor biased below cutoff by a -12-volt base supply. When 0 inputs are applied to all of the NOR gate input leads, the net base potential is negative, the transistor is cut off, and a 1 is present at the output. When a 1 is applied to any of the input terminals the base becomes positive - coupling resistors isolate all other 0 inputs - and the transistor turns on. The output drops to ground potential (nominally), and a 0 is present at the output.

3-37. Figure 3-8 shows the sweep control circuit for both analyzer and synchroscope modes of operation. The analyzer mode is discussed first. SWEEP time switch S2 is set to any of the analyzer positions (MS/DIV) and SWEEP/SYNC switch S3 is set to INT SWEEP (black). Because of the interdependency of the sweep generation circuit and the sweep control circuit, logic diagram analysis of the control circuit begins at an arbitrary point in the recurring sequence that constitutes a sweep cycle; sweep gate flip flop A5Q12/A5Q11 is set and a sawtooth is being generated in the sweep generation circuit. (A 1 output is provided by A5Q12 and a 0 output is provided by A5Q11.) When the sawtooth becomes sufficiently positive, the sweep input from A5Q30 trips Schmitt Trigger A5Q31/A5Q32 which produces a 1 output that is inverted by A5Q33. The Schmitt trigger output, representing full-scale deflection of the sweep is used to generate a blanking pulse concurrent with retrace. The output from A5Q33 is inverted in the NOR gate A5Q21 because a 0 output is also coupled through A5Q26 from +12 volt potential on the wiper arm of SWEEP switch S2B. The 1

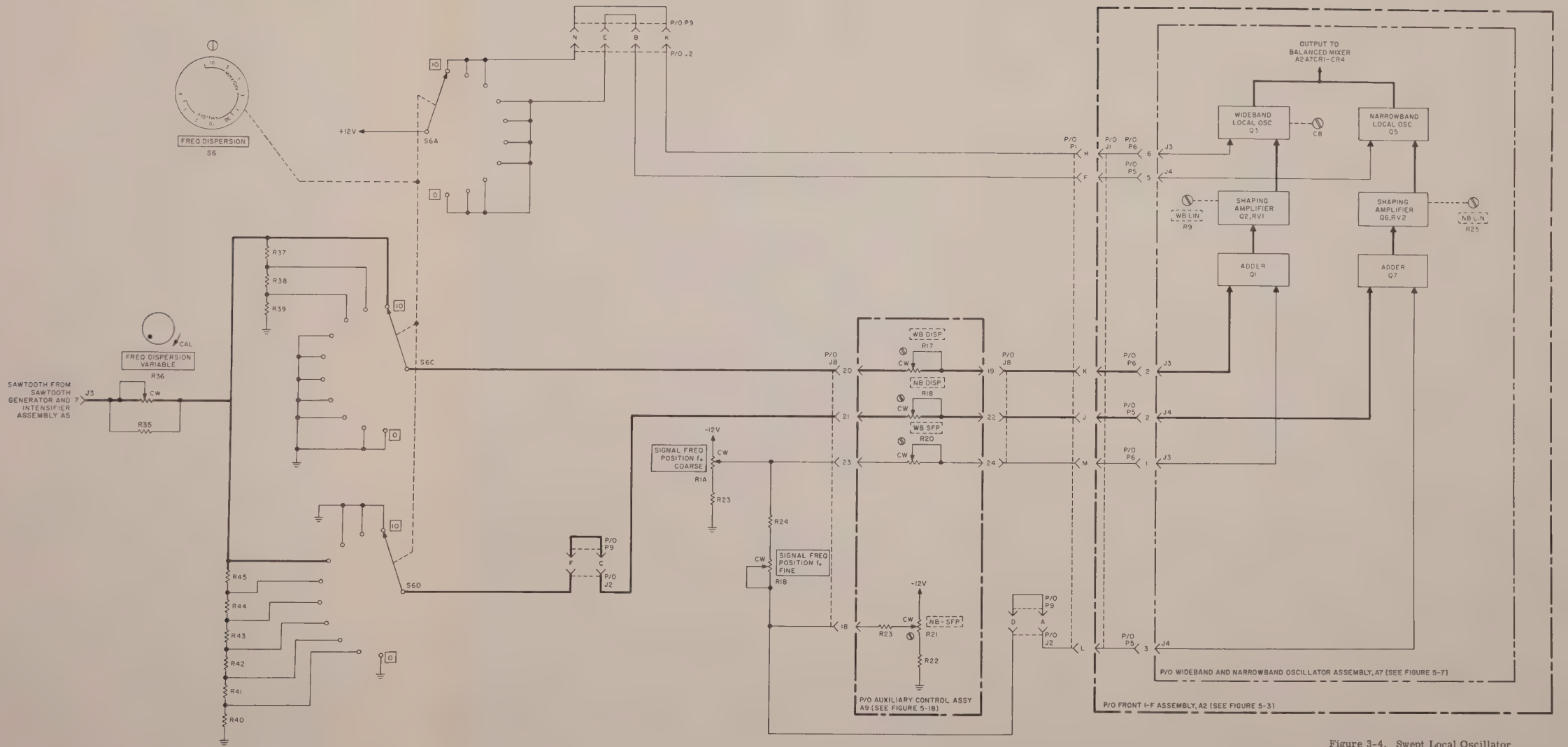


Figure 3-4. Swept Local Oscillator Circuitry, Detailed Block Diagram

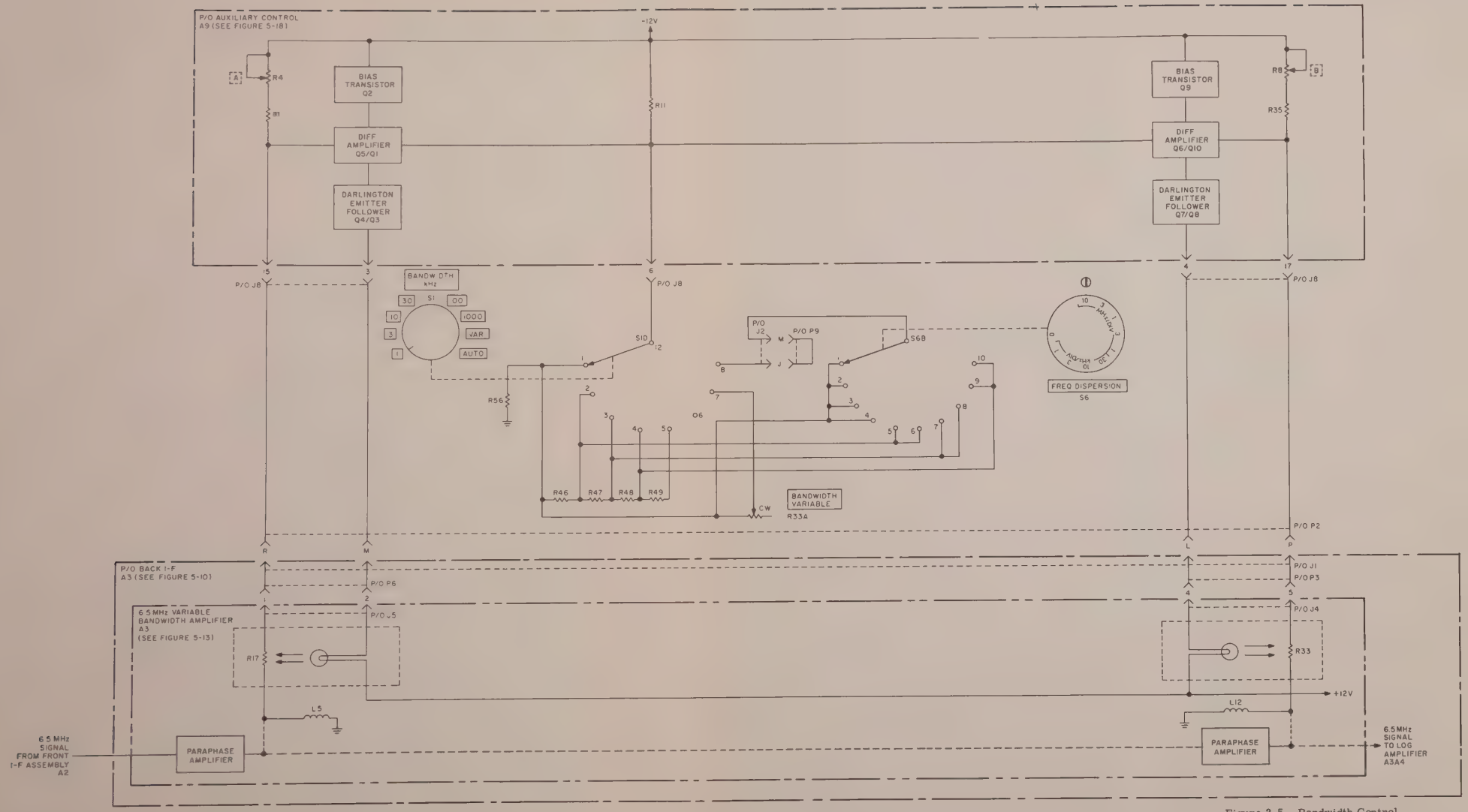


Figure 3-5. Bandwidth Control Circuitry, Detailed Block Diagram

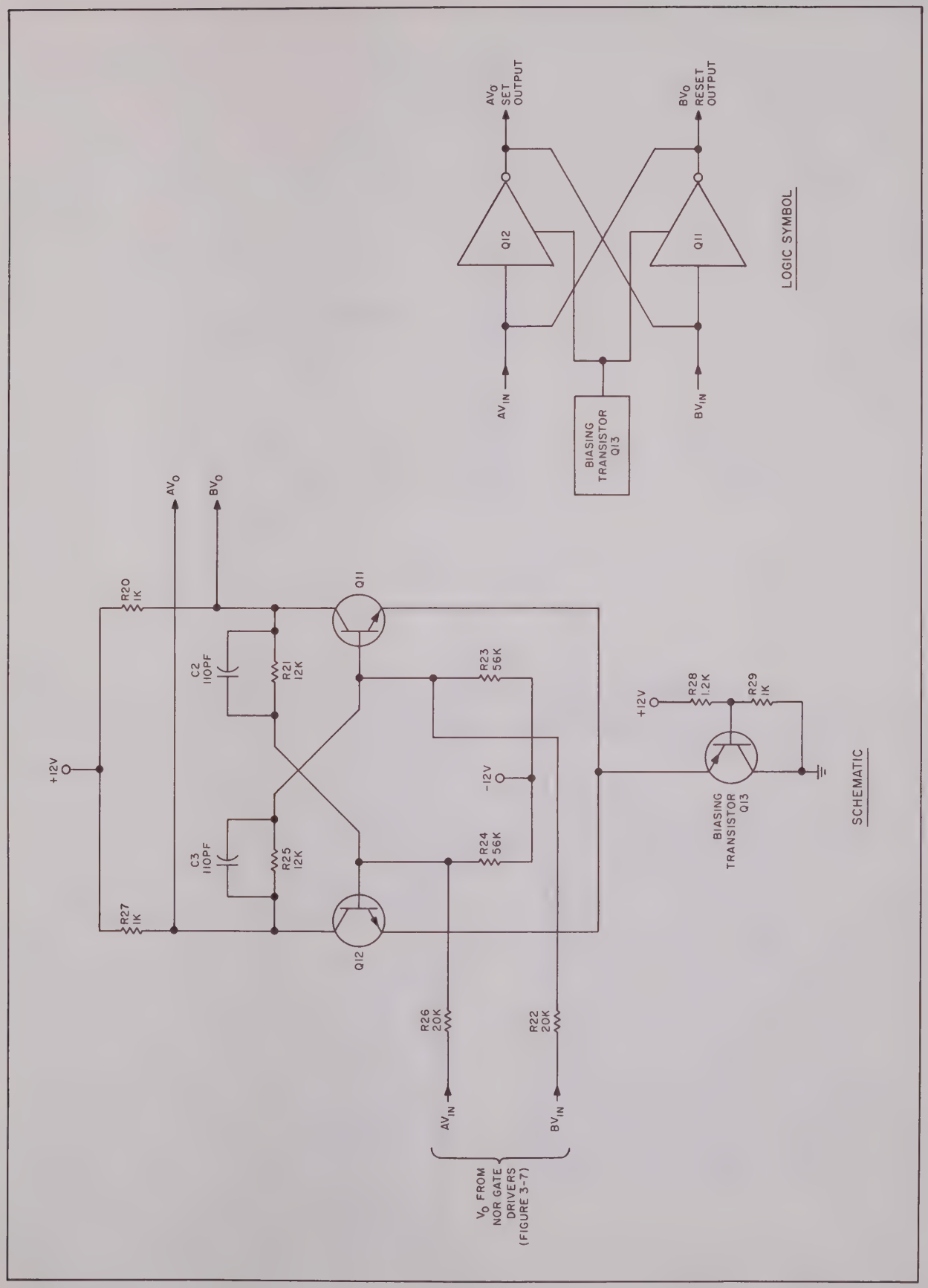


Figure 3-6. Sweep Gate Flip-flop

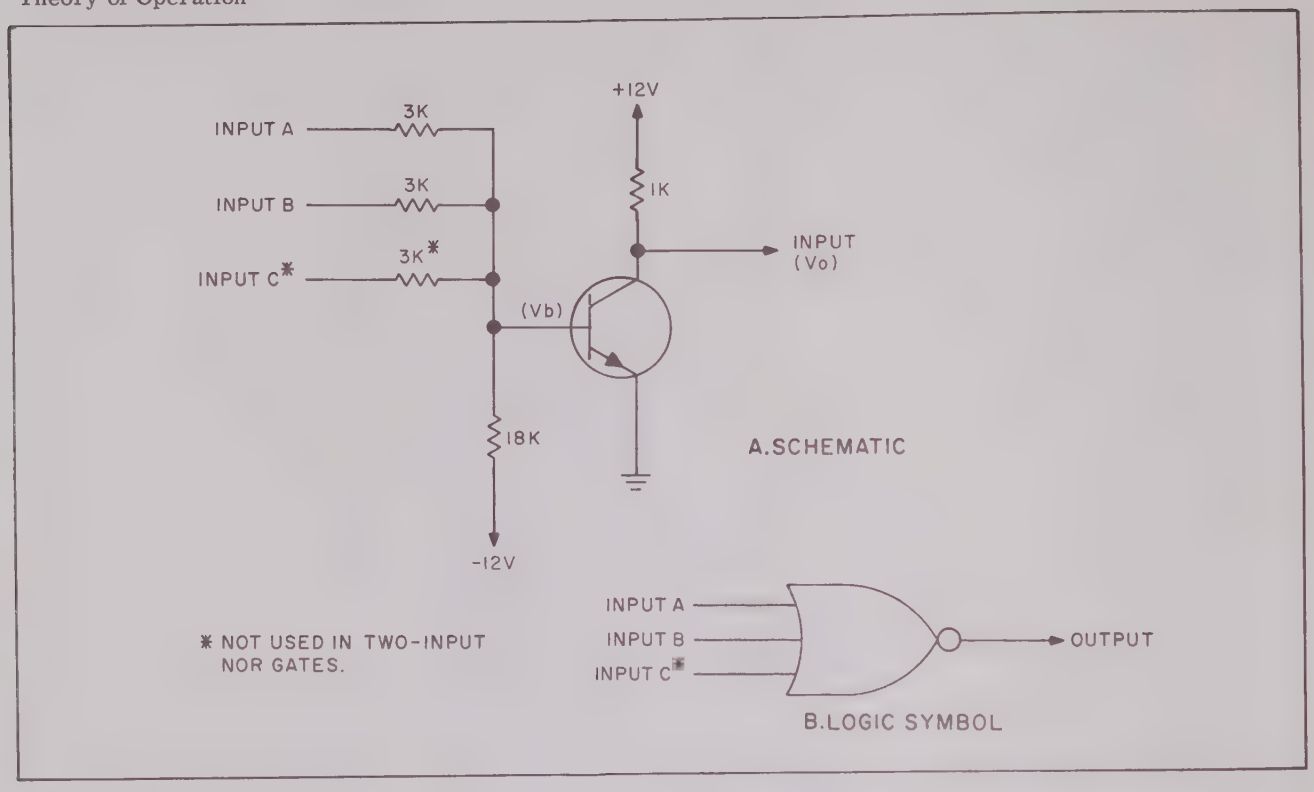


Figure 3-7. Basic NOR Gate

applied to NOR gate A5Q20, (other inputs are 0), produces the required 0 base input to A5Q11 necessary to reset the sweep gate transistor and apply a blanking pulse to the CRT circuit.

3-38. A measured time interval must lapse before the next sweep gate is issued, to permit full retrace after the blanking pulse is initiated. One shot A5Q38/A5Q39 provides this time interval. The 0 output from inverter A5Q33, which initiated the blanking pulse, is also applied to NOR gate A5Q28. Concurrently, a 1 from the wiper arm of SWEEP/SYNC switch S3C is inverted when coupled through NOR gate A5Q27 to A5Q28. Both inputs to A5Q28 generate a 1 output which triggers one shot A5Q38/A5Q39. The one shot output is a 0, coupled through inverter A5Q25, and the resultant 1 output is again inverted when coupled through NOR gate A5Q23. The 0 output of A5Q23 is inverted and applied as a 1 to the base of sweep gate transistor A5Q12 permitting this transistor to be reset, (refer to paragraphs 3-33 and 3-34) which results in the discharge of the sawtooth and in turn returns Schmitt trigger A5Q31/32 to its quiescent state. The 0 output of this Schmitt trigger results in a 1 input to sweep gate transistor A5Q12. Consequently, for as long as the one shot output is 0, the sweep gate flip flop remains reset to permit full retrace.

3-39. When the one shot output returns to the quiescent 1 output, a 0 is applied to the base of A5Q12 and the sweep gate flip flop is set. The time duration of the one shot output is unaffected by timing switch A5Q40 whenever a 1 is applied to the switch, and when SWEEP switch S2B is in any of the analyzer positions, a 1 is always applied to the timing switch. In the analyzer mode of operation the one-shot output pulse is relatively long so that not only retrace time is available, but also, the current-sensitive inductor in the wideband local oscillator (which could be selected in analyzer operation) has sufficient time for its current flow at the end of each sweep - to build up to its initial value before a new sweep is started. This process is repeated for each sweep.

3-40. When the analyzer is operated with SWEEP/SYNC switch S3 in any of the sync positions (red EXT, INT, USE or CAL) or in the SINGLE position, the sweep gate flip flop is not operated as a standard toggle flip flop; and when a blanking pulse is initiated (A5Q11 is cutoff) the sweep gate output (A5Q12 also cutoff) can be available. As in the previous paragraphs, the 0 output of inverter A5Q33 results in a blanking pulse; but, in sync operation one shot A5Q38/A5Q39 is not tripped; therefore the 0 input to the base of A5Q12 remains, keeping that transistor cut off. The 1 output of A5Q12 remains until the 0 input applied to its base is removed. To trip the one shot, a 1 output from A5Q28 is required and it is only made available after other actions are taken. The 0 output from A5Q33 cannot produce a 1 output from NOR gate A5Q28 because the output of NOR gate A5Q27

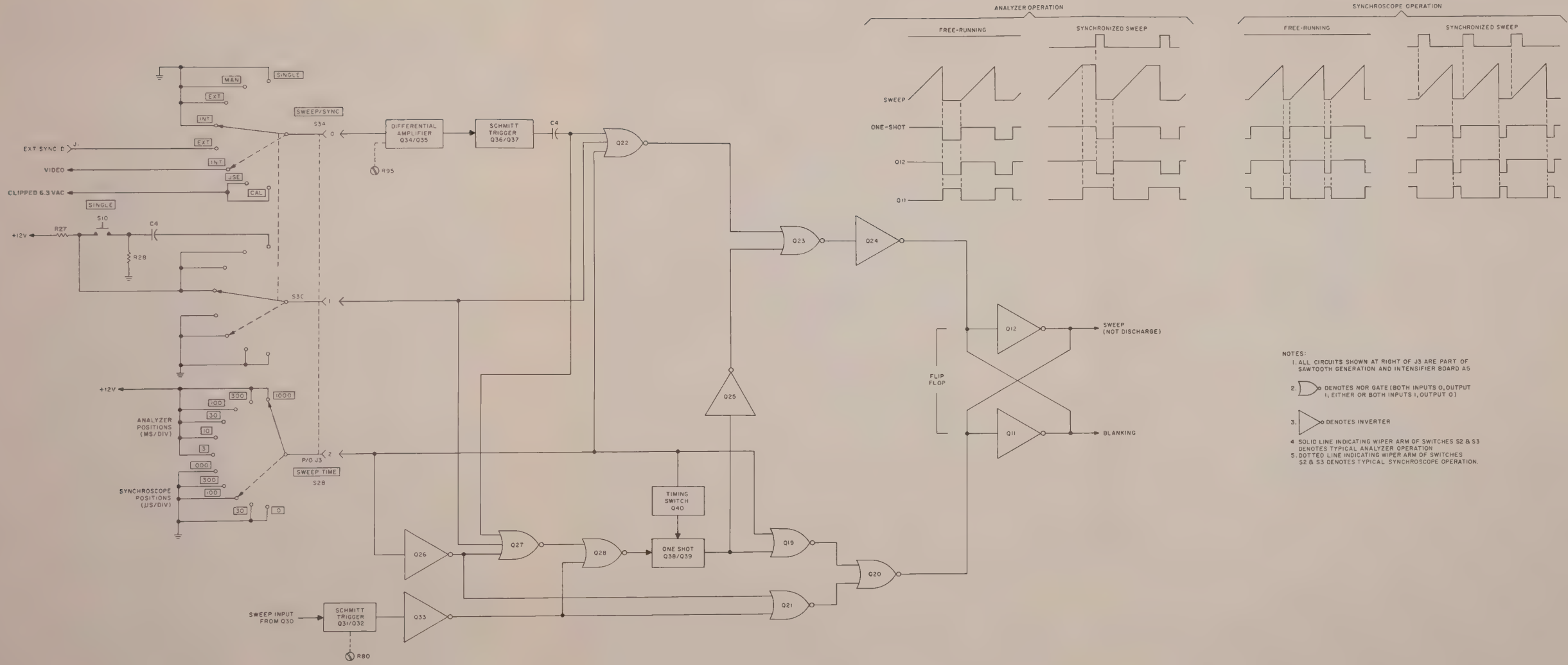


Figure 3-8. Sweep Control Circuitry, Detailed Block Diagram

is a 1 (all of its inputs are 0's: the output of Schmitt trigger A5Q36/Q37 is a 0 in the absence of a sync pulse; the input from SWEEP/SYNC switch S3C is a 0, assuming that SINGLE pushbutton S10 has not been pressed; and the output of inverter A5Q20 is a 0 when any of the analyzer positions of SWEEP switch A2 are selected). When the SINGLE pushbutton is pressed, a 1 is capacitively coupled to the contacts of switch S3C which applied it to NOR gate A5Q27, one shot A5Q38/39 is tripped, and the sweep gate output is terminated (A5Q12 is turned on). The sweep gate becomes available again when the one-shot pulse ends. In addition to SINGLE position operation, synchronizing pulses for sweep gate termination can be coupled through the contacts of SWEEP/SYNC switch S3A to differential amplifier A5Q34/Q35. If the sync pulse amplitude is above a preset level set by potentiometer R95, Schmitt trigger A5Q36/Q37 is tripped. The resultant 1 output of the Schmitt trigger is coupled through capacitor C4 to NOR gate A5Q27. Sweep gate termination takes place, for one shot A5Q38/39 is tripped by coupling the sync pulse through NOR gates A5Q27 and A5Q28 (previously described).

3-41. When SWEEP switch S2B is set to any of the synchroscope, uS/DIV positions, SWEEP/SYNC switch S3A is usually set to a sync position (red EXT, INT or USE). A sync pulse is then used to initiate the sweep gate, while retrace and blanking occur when the sweep sawtooth voltage indicates full-scale deflection. During synchroscope operation NOR gate A5Q21 is by-passed and the output of one shot A5Q38/Q39 is used both for blanking and sweep gate termination. The 0 output from inverter A5Q33, indicating full-scale sweep deflection, is applied to NOR gate A5Q28. The other input to this NOR gate is always a 0 in synchroscope operation, for the wiper arm of switch S2B is always at 0; and through the double coupling of inverter A5Q26 and NOR gate A5Q27, a 0 is applied to NOR gate Q28. Therefore the output of NOR gate A5Q28 becomes a 1 when the sweep reaches full-scale deflection. A 1 is produced at the output and one shot A5Q38/Q39 is triggered. The resultant 0 output pulse is applied to NOR gate A5Q19, for blanking, and inverter A5Q25, to permit sweep gate termination. With 0 inputs applied to A5Q19 a 1 becomes its output which is inverted and coupled through NOR gate A5Q20 to reset sweep gate flip flip A5Q11/Q12. (The other input to NOR gate A5Q20 is always a 0 in this mode because of the SWEEP switch setting.) The sweep gate flip flop is able to reset (both stages change state) because the one shot 0 output is inverted and coupled through each of stages inverter A5Q25, NOR gate A5Q23 and inverter A5Q21 to place a 1 on the base of transistor A5Q12. (Refer to paragraph 3-34 for a discussion of the flip flop operation.)

3-42. Timing switch Q40, enabled by a 0 input from SWEEP switch S2B, changes the rc time constant of one shot A5Q38/Q39 to reduce the time duration of the one shot output. The shorter time duration allows for the faster sweep rates employed in the synchroscope mode of operation. After retrace, the next sweep is begun by the application of an incoming sync pulse to differential amplifier A5Q34/A5Q35 which in turn trips Schmitt trigger A5Q36/Q37. Capacitor coupling applies a 1 to NOR gate A5Q22. The NOR gate inverts the 1 input (all other inputs from switches S3C and S2B are 0's) and applies a 0 to NOR gate A5Q23; the one shot has returned to the stable 1 state and inverter A5Q25 has a 0 output. The output from A5Q23 is a 1, inverted by A5Q24 and a 0 is applied to the base of A5Q12 setting the sweep gate flip flop. Both flip flop stages change state, initiating the sweep gate and terminating the blanking pulse, for the 0 input is removed from the base of A5Q11 when the one shot output coupled through A5Q19 and A5Q20 returns to the 1 level. In synchroscope operation, the time between sweeps is kept to a minimum for the CRT brightness would be too low, if, at high sweep speeds, the time between sweeps is kept relatively long.

3-43. When the unit is used as a standard free-running oscilloscope or a high-sweep-speed analyzer, the SWEEP/SYNC switch is set to INT SWEEP (black). Sweep gate termination and blanking initiation takes place in the same manner described for synchroscope operation (paragraph 3-31 through 3-39). However, sweep gate initiation and blanking termination are caused by the trailing-edge of the one shot output pulse similar to analyzer operation. The output of NOR gate A5Q22 is a 0 for SWEEP/SYNC switch S3C applies a 1 input to the NOR gate; and the output of inverter A5Q25 is also a 0 when the one shot output is terminated. All 0 inputs to NOR gate A5Q23 apply a 1 to inverter A5Q24 where the signal is inverted, applying a 0 set pulse to the base of A5Q12. The sweep trace begins again.

Note

High-speed analyzer operation should be restricted to narrow-band operation since the one-shot pulse duration is not sufficient in high speed to enable the current in the current-controlled inductor of the wideband local oscillator to reach its maximum value in the limited time between successive sweeps.

3-44. Sweep Generator. The sweep generator (figure 3-9) consists of a constant current charge circuit comprising the sweep capacitor (C1, C2, or C3) selected by SWEEP switch S2A, constant current source A5Q16, and the sweep resistor R18, R16, R17, or R15) selected by SWEEP switch S2C. The rate at which the sweep voltage increases - the sweep capacitor charge rate - depends upon the capacitance of the selected sweep capacitor, and the current in A5Q16. The current is determined by the resistance of the selected sweep resistor and the voltage applied to the base of A5Q16 by SWEEP VARIABLE control R14. The more negative the base voltage, the greater the current in A5Q16 and the faster the sweep. SWEEP CAL screwdriver adjustment A9R24 calibrates the SWEEP switch positions when the SWEEP VARIABLE control is fully cw.

3-45. When the positive sweep gate is applied from sweep gate flip-flop A5Q11/Q12, A5Q14 is held off; and as a result, A5Q15 is held off. Diode A5CR1

blocks the positive voltage at the collector of A5Q15 from the sweep circuit. During the sweep gate interval, the sweep capacitor is charged through the series network consisting of selected resistor R15 through R18, constant current source A5Q16, and A5Q17 of the biasing network causing a sawtooth voltage to be developed across the sweep capacitor. The sum of this sawtooth voltage and the negative dc bias established by the biasing network Q17/Q18 make up the sweep voltage which is coupled through the contacts of SWEEP/SYNC switch S3D (except in MAN and EXT SWEEP) to an emitter follower output circuit. The biasing network is a complementary emitter follower whose output is set by screwdriver adjustment A5R37. When A5Q12 of the sweep control circuit is turned on, its output becomes 0, turning on A5Q14, which in turn turns on A5Q15, which discharges the sweep through the capacitor and retrace occurs.

3-46. Darlington emitter follower A5Q29, in series with A5Q30, applies the buffered output to the sweep control circuits, to the swept local oscillator circuits, and to the horizontal deflection circuits. The adjusted output of the H SIZE potentiometer is applied through the horizontal deflection amplifier in assembly A4 to the CRT. This adjustment, A5R37, establishes the position of the left edge of the trace. The portion of the sweep voltage developed across R30 is applied to the H output pin J1-A, for remote operation or X-Y plotting.

3-47. In MAN, the sweep voltage is a dc voltage that can be varied by SWEEP MANUAL control R26; as before the biasing network established the minimum voltage for the sweep. In the black EXT position, an external sweep applied at J1-E, replaces the internally developed sweep.

3-48. INTENSIFICATION CIRCUITS. The intensification circuits produce an output to the CRT control grid that blanks the screen when the sweep capacitor is not being charged, intensifies the trace in accordance with the BRIGHTNESS control setting, or intensifies only signals whose amplitudes exceed a value set by the INTENSIFIER control. Figure 3-10 is the detailed block diagram of the intensification circuits.

3-49. The video output of the auxiliary output amplifier A4Q4, Q5, and Q6 is applied to one input of differential amplifier A5Q2/Q3 where it is compared with the dc voltage established by the setting of the INTENSIFIER control. If the INTENSIFIER is set fully ccw, the output of difference amplifier A5Q2/Q3 is always positive, and the output of Schmitt trigger A5Q4/Q5 (held in the "triggered" state) is a positive dc voltage. This dc output of A5Q4/Q5 turns on pulse amplifier A5Q6, which is a common-base amplifier whose dc base voltage is determined by the setting of the BRIGHTNESS control. When the INTENSIFIER control is turned clockwise, any video components that are greater in amplitude than the intensifier voltage produce a positive pulse output from the differential amplifier. This positive output triggers Schmitt trigger A5Q4/Q5 which produces a positive pulse. This positive pulse turns on pulse amplifier A5Q6 which gates the voltage determined by the setting of the BRIGHTNESS control. The output of the pulse amplifier therefore is a positive pulse or a dc level whose amplitude is established by the BRIGHTNESS control. This positive pulse or dc level is applied to differential amplifier A5Q7/Q8 whose second input is the blanking pulse that is applied from flip-flop A5Q11/Q12 through emitter follower A5Q16. During the time of the blanking pulse, the output of the differential amplifier is a negative-going pulse; during each sweep, the output of the differential amplifier is a dc level that is too low to intensify the screen except when a video pulse exists that exceeds the voltage set by the INTENSIFIER control; at this time, the output is controlled by the setting of the BRIGHTNESS control. This composite signal is applied through emitter follower A5Q9 and the output circuit of the 2500 volt power supply to the control grid of CRT V1. The voltage applied to the CRT grid is therefore 2500 volts plus the output of emitter follower A5Q9; this configuration permits the CRT grid to be operated at approximately 2500 volts while the circuits in the sawtooth generator intensifier board A5 operate at normal transistor voltages.

3-50. POWER SUPPLIES. The dc power supplies in the Main Frame include the +300 volt unregulated, +100 volt regulated, +12 volt regulated, -12 volt regulated, and high voltage CRT power supplies. These supplies provide the operating voltages for the Main Frame and for the associated tuning head. In addition, +18 volts unregulated from the rectifier and filter of the +12 volt supply is applied to the tuning head.

3-51. Input Circuit (figure 5-1). 115 volt or 230 volt single-phase ac power is applied from power plug P8 through fuses F1 and F2, power switch S7 (ganged to the SCALE ILLUMINATION control), and 115V--230V switch S9 to power transformer T1. When S9 is set to 115V, the two primary windings of T1 are connected in parallel and, with a 115 volt input, the voltage across each winding is 115 volts. When S9 is set to 230 V, the windings are connected in series and, with a 230 volt input, the voltage across each winding is 115 volts. The series-circuit current is equal to the current that would flow in each of the parallel-connected windings. Thus, the input current in 230-volt operation is half that in 115-volt operation. To maintain the same degree of protection in 230-volt operation, the current rating of the fuses should be half that of the fuses used in 115-volt operation.

3-52. +300 Volt Power Supply. The +300 volt power supply contains full-wave rectifier A7CR1, CR2, filter A7C1, R1, C2, and bleeder resistor A7R2.

3-53. +100 Volt Power Supply. The +100 volt power supply contains full-wave rectifier A7CR3, CR4, filter capacitor A7C3, bleeder resistor A7R3, fuse A7F1, and a voltage and current regulator consisting of circuits on board A8 and power transistor (series regulator) Q5. The regulator circuit

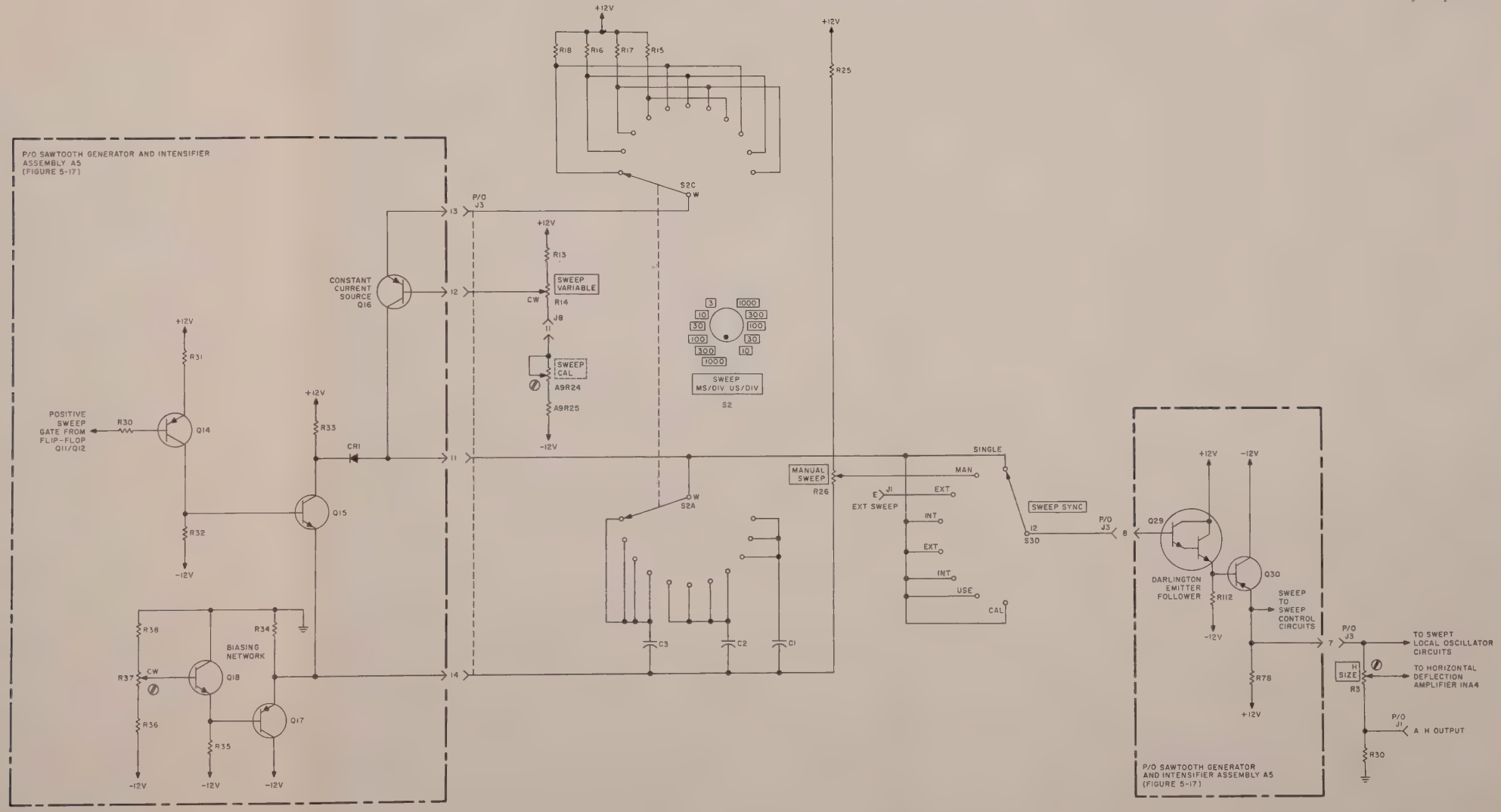


Figure 3-9. Sawtooth Generator Circuitry, Detailed Block Diagram

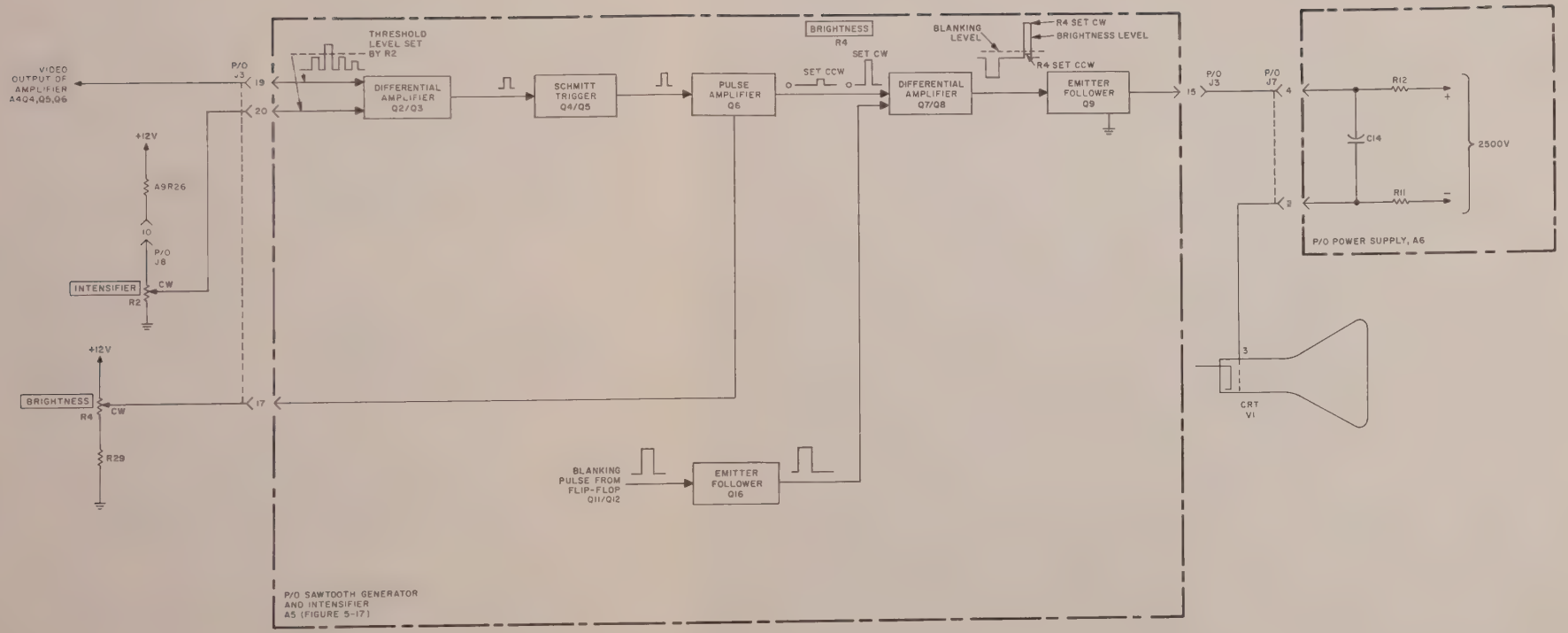


Figure 3-10. Intensifier and Blanking Circuitry, Detailed Block Diagram

controls the conduction through Q5 to regulate the output voltage and current. If the output voltage rises slightly, the voltage applied to difference amplifier A8Q4/Q3 rises, conduction in A8Q4 increases, increasing the drop across collector load resistors A8R1 and A8R2, and decreasing its collector voltage. As a result, the base voltage of A8Q1 decreases, decreasing conduction in emitter follower A8Q1 and in series regulator Q5. Turning screwdriver adjustment A8R10 counterclockwise has the same effect on the regulator as an increased output voltage would (increasing the voltage at A8Q4), and the regulator therefore reduces the output voltage to compensate for such an adjustment. If the load current increases slightly, it would produce an increased voltage drop across A8R5, which would increase conduction in A8Q2, whose reduced collector voltage would reduce conduction in emitter follower A8Q1 and in series regulator Q5.

3-54. +12 Volt and -12 Volt Power Supplies. The +12 volt and -12 volt supplies are identical; therefore only the +12 volt supply is described. A portion of the positive output is sensed by the voltage divider consisting of A8R18, R19, and R20. This voltage is applied to difference amplifier A8Q6/Q7 where any change is compared with the reference supplied by Zener diode CR3. The amplified voltage change (in phase) from A8Q6 is applied through emitter follower A8Q5 to the base of series regulator Q2. If the output voltage rises, the base voltage of Q2 increases and conduction in Q2 decreases returning the output voltage to +12 volts. If the output current increases, the voltage across A8R10 increases, decreasing conduction in series regulator Q1.

3-55. CRT Power Supplies. The CRT power supplies utilize a square-wave oscillator whose output is stepped up by transformer T1 to the high voltage ac, which is rectified by a voltage doubler and filtered to provide +2500 volt and -2500 volt outputs. The oscillator is a free-running multivibrator with a RC time constant in the base drive, which determines the frequency of oscillation. Diodes A6CR7, CR8 serve to protect the base emitter junction from reverse breakdown. When power is first applied, capacitors A6C5 and A6C4 start to charge through A6R2 and trigger unijunction transistor A6Q3. The pulses generated by A6Q3 trigger A6Q1 to ensure operation of the free-running multivibrator. After a few cycles of operation, the charge across A6C5 will have built up sufficiently to block the unijunction circuit; the multivibrator continues to operate without this triggering. When the equipment is turned off, capacitor A6C5 discharges rapidly through A6CR1 so that the unijunction circuit will operate immediately upon re-energization. The frequency at which the oscillator operates (approximately 20 kHz) is not critical since the output is rectified to produce the dc supply voltages.

3-56. POWER DISTRIBUTION.

3-57. The source and distribution of dc voltages are listed in table 3-1. Table 3-1 lists all circuit boards and other reference-designated assemblies and indicates which, if any, of the dc voltages are used in each. For complete interconnections, refer to figures 5-1, 5-3, and 5-10.

TABLE 3-1. DC VOLTAGE DISTRIBUTION

Board (Mating connector)	Pin at which Voltage is Connected				
	+300V (A7-6)	+100V (A8-11)	+12V (A8-23)	-12V (A8-2)	GND
A1	-	-	-	-	-
A2(P1)	-	D	C	B	A
A2A1(A2P2)	-	-	3	-	1
A2A2(A2P3)	-	-	-	-	1
A2A3(A2P4)	-	-	1	-	2
A2A4	-	-	-	-	-
A2A5	-	-	-	-	-
A2A6	-	-	-	-	-
A2A7	-	A2P5-1	A2P6-5	A2P6-4	A2P6-3
A2A8(A2P7)	-	-	1	2	4
A2A9(A2P8)	-	-	3	1	2

TABLE 3-1. DC VOLTAGE DISTRIBUTION (Cont'd)

Board (Mating connector)	Pin at which Voltage is Connected				
	+300V (A7-6)	+100V (A8-11)	+12V (A8-23)	-12V (A8-2)	GND
A3(P2)	-	-	C	B	A
A3A1(A3P1)	-	-	-	1	3
A3A2(A3P2)	-	-	-	1	2
A3A3(A3P3)	-	-	3	7	1
A3A4(A3P4)	-	-	3	1	2
A3A5(A3P5)	-	-	1	3	2
A4(J4)	14	-	7	9	5, 11
A5(J3)	-	16	9, 18	4, 21	5, 22
A6(J7)	-	-	21	22	15, 20
A7(J5)	-	-	-	-	
A8(J6)	-	-	-	-	9
A9(J8)	9	-	1, 13	5	2

SECTION IV
MAINTENANCE

4-1. GENERAL.

4-2. This section contains maintenance, alignment and calibration instructions for the MF-100. Included is a list of test equipment necessary to maintain the MF-100, minimum performance standards checks to evaluate if the MF-100 operates within the specifications listed in paragraph 1-7, symptomatic troubleshooting procedures to localize a malfunction to an individual circuit or subassembly and alignment and calibration procedures necessary to restore the MF-100 to proper operating condition after the required repairs and/or replacements have been effected.

4-3. REQUIRED TEST EQUIPMENT

4-4. The test equipment required for the maintenance of the MF-100 is listed in table 4-1. Equipment having equivalent characteristics may be substituted for those specified.

4-5. MINIMUM PERFORMANCE STANDARDS CHECKS.

4-6. The minimum performance standards checks is a systematic procedure for determining if the MF-100 is operating within the specifications listed in paragraph 1-7. Should the MF-100 fail to provide the specified "acceptable indication," the equipment is not functioning properly and the operator should refer to the applicable troubleshooting, replacement, repair, alignment and/or calibration procedure to return the equipment to proper operating condition. Set the MF-100 controls as listed in table 4-2 prior to initiating the minimum performance standards checks detailed in table 4-3.

TABLE 4-1. REQUIRED TEST EQUIPMENT

Manufacturer and Model
Hewlett-Packard 608C Signal Generator
Tektronix Type 180A Time-Mark Generator
Hewlett-Packard 8406A Comb Generator
Hewlett-Packard 651B Test Oscillator
Narda 501B Detector
Microlab DA-3FB Resistive T
Hewlett-Packard 130C Oscilloscope
Kay 33-0(432C) Step Attenuator
Kay 70-0(1/432C) Step Attenuator
Jerrold 900B Sweep Signal Generator
RCA WV98C Senior Voltohmyst
Hewlett-Packard 132A Dual Beam Oscilloscope
Hewlett-Packard 606B Signal Generator
The Singer Company-Empire F-1A/NF-105 Tunable Rejection Filter

TABLE 4-2. INITIAL CONTROL SETTINGS FOR MINIMUM PERFORMANCE STANDARDS CHECKS

Control	Setting
SCALE ILLUMINATION control	Fully ccw (PWR OFF)
FOCUS control	Mid-range
BRIGHTNESS control	Mid-range
INTENSIFIER control	Fully ccw
IF ATTENUATOR switches	00 dB
FREQ DISPERSION switch	.3 MHz/DIV

TABLE 4-2. INITIAL CONTROL SETTINGS FOR MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Control	Setting
FREQ DISPERSION VARIABLE control	Fully cw (CAL)
MARKER MODULATION switch	OFF
MARKER LEVEL control	Fully ccw (OFF)
AMPLITUDE SCALE switch	LOG
IF GAIN control	Fully ccw
SIGNAL FREQ POSITION f_0 COARSE control	Mid-range
SIGNAL FREQ POSITION f_0 FINE control	Mid-range
BANDWIDTH switch	100 kHz
BANDWIDTH VARIABLE control	Fully cw
SWEEP switch	3 MS/DIV
SWEEP VARIABLE control	Fully cw (CAL)
SWEEP/SYNC switch	INT SWEEP (black)
MANUAL control	Any

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS

Step	Purpose	Procedure	Acceptable Indication
1	Preparation for checkout.	Couple the MF-100 to line power, rotate the SCALE ILLUMINATION control clockwise from its PWR OFF setting and adjust for a convenient graticule illumination. Allow the MF-100 to warm up for at least 10 minutes. Adjust the FOCUS and BRIGHTNESS controls to obtain a sharply focused and clearly visible trace. Rotate the IF GAIN control clockwise so that the bottom of the trace coincides with the LOG scale 60 DB line. Adjust the H POS screwdriver control to center the display on the screen and then adjust the H SIZE screwdriver control so that the waveform extends one-quarter division beyond the extreme left- and right-hand vertical graticule lines. Rotate the IF GAIN control fully counterclockwise and adjust the V POS screwdriver control so that the base of the displayed waveform coincides with the lowest horizontal graticule line. Tune an HP 608C Signal Generator to 160 MHz and adjust for a cw output level of -45 dBm. Couple the signal generator to the rear panel IF INPUT connector. Adjust the SIGNAL FREQ POSITION f_0 COARSE and/or FINE control to center the displayed pip about the vertical graticule f_0 line.	Proper display is presented on screen.

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
2	To evaluate accuracy of LOG display.	a. Insert Kay 33-0(432C) and 70-0(1/432C) Step Attenuators in series between the signal generator and the MF-100 rear panel IF INPUT connector. Adjust the step attenuators for 0-dB insertion. Set the FREQ DISPERSION switch to .1 MHz/DIV and adjust the IF GAIN control to obtain a noise display one box high. Reset the BANDWITH switch to 10 kHz and adjust the signal generator output level to obtain a pip peak coincident with the LOG scale 0 dB line. Note the signal generator output level.	a. Signal level required for full-scale LOG display is between -40 and -50 dBm.
		b. Insert external step attenuation until the pip peak is coincident with the LOG scale 10 dB line. Note the total external attenuation inserted.	b. Between 8 and 12 dB of external step attenuation required to position the pip peak at the LOG scale 10 dB line.
		c. Insert additional external step attenuation until the pip peak is coincident with the LOG scale 20 dB line. Note the total external attenuation inserted.	c. Between 18 and 22 dB of external step attenuation required to position the pip peak at the LOG scale 20 dB line.
		d. Insert additional external step attenuation until the pip peak is coincident with the LOG scale 30 dB line. Note the total external attenuation inserted.	d. Between 28 and 32 dB of external step attenuation required to position the pip peak at the LOG scale 30 dB line.
		e. Insert additional external step attenuation until the pip peak is coincident with the LOG scale 40 dB line. Note the total external attenuation inserted.	e. Between 38 and 42 dB of external step attenuation required to position the pip peak at the LOG scale 40 dB line.
		f. Insert additional external step attenuation until the pip peak is coincident with the LOG scale 50 dB line. Note the total external attenuation inserted.	f. Between 48 and 52 dB of external step attenuation required to position the pip peak at the LOG scale 50 dB line.
		g. Insert additional external step attenuation until the pip peak is coincident with the LOG scale 60 dB line. Note the total external attenuation inserted.	g. Between 58 and 62 dB of external step attenuation required to position the pip peak at the LOG scale 60 dB line.
3	To evaluate range of IF GAIN control.	a. Adjust the external step attenuators for 0 dB insertion, rotate the IF GAIN control fully counterclockwise and adjust the signal generator output level to obtain a pip peak coincident with the LOG scale 20 dB line.	
		b. Rotate the IF GAIN control fully clockwise and insert external step attenuation to once again obtain a pip peak coincident with the LOG scale 20 dB line. Note the total external attenuation inserted.	b. At least 20-dB of external attenuation required to return the pip peak to the LOG scale 20 dB line.
4	To evaluate accuracy of LIN display.	a. Set the IF ATTENUATOR switches to 40 dB, set the external step attenuators for 0 dB insertion, set the AMPLITUDE SCALE switch to LIN and rotate the IF GAIN control fully counterclockwise. Adjust the V POS screwdriver control, if necessary, to position the	

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
4 (Cont)		base of the displayed waveform coincident with the lowest horizontal graticule line. Adjust the signal generator output level to obtain a pip peak coincident with the LIN scale 1.0 line.	
		b. Insert external step attenuation until the pip peak is coincident with the LIN scale 0.8 line. Note the total external attenuation inserted.	b. Between 1.6 and 2.2 dB of external step attenuation required to position the pip peak at the LIN scale 0.8 line.
		c. Insert additional external step attenuation until the pip peak is coincident with the LIN scale 0.6 line. Note the total external attenuation inserted.	c. Between 4.0 and 4.9 dB of external step attenuation required to position the pip peak at the LIN scale 0.6 line.
		d. Insert additional external step attenuation until the pip peak is coincident with the LIN scale 0.4 line. Note the total external attenuation inserted.	d. Between 7.2 and 8.6 dB of external step attenuation required to position the pip peak at the LIN scale 0.4 line.
		e. Insert additional external step attenuation until the pip peak is coincident with the LIN scale 0.2 line. Note the total external attenuation inserted.	e. Between 12.8 and 15.4 dB of external step attenuation required to position the pip peak at the LIN scale 0.2 line.
5	To evaluate accuracy of PWR display.	a. Set the external step attenuators for 0 dB insertion, set the AMPLITUDE SCALE switch to PWR and, if necessary, adjust the V POS screwdriver control to position the base of the displayed waveform coincident with the lowest horizontal graticule line. Adjust the signal generator output level to obtain a pip peak coincident with the PWR scale 1.0 line.	
		b. Insert additional external attenuation until the pip peak is coincident with the PWR scale 0.6 line. Note the total external attenuation inserted.	b. Between 2.0 and 2.4 dB of external step attenuation required to position the pip peak at the PWR scale 0.6 line.
		c. Insert additional external attenuation until the pip peak is coincident with the PWR scale 0.4 line. Note the total external attenuation inserted.	c. Between 3.6 and 4.3 dB of external step attenuation required to position the pip peak at the PWR scale 0.4 line.
		d. Insert additional external attenuation until the pip peak is coincident with the PWR scale 0.2 line. Note the total external attenuation inserted.	d. Between 6.4 and 7.7 dB of external step attenuation required to position the pip peak at the PWR scale 0.2 line.
6	To evaluate accuracy of i-f attenuator.	a. With the AMPLITUDE SCALE switch set to PWR, insert a total of 66 dB of external step attenuation, adjust the signal generator for a cw output of +5 dBm and adjust the IF GAIN control to obtain a pip peak coincident with the PWR scale 1.0 line.	

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
6 (Cont)		b. Set the IF ATTENUATOR switches as indicated below and, for each setting, remove external step attenuation until the pip peak is coincident with the PWR scale 1.0 line. Note the remaining external attenuation inserted after each step. IF ATTENUATOR Switch Setting 10 DB 20 DB 30 DB 40 DB 50 DB 60 DB	b. IF ATTENUATOR Switch Setting / Remaining External Step Attenuation 10 DB — 55.5 to 56.5 dB 20 DB — 45.0 to 47.0 dB 30 DB — 34.5 to 37.5 dB 40 DB — 24.0 to 28.0 dB 50 DB — 13.5 to 18.5 dB 60 DB — 3.0 to 9.0 dB
		c. Reset the external step attenuators for 66 dB insertion, set the IF ATTENUATOR switches to 00 DB and adjust the IF GAIN control, if necessary, to obtain a pip peak coincident with the PWR scale 1.0 line.	
		d. Set the IF ATTENUATOR switches as indicated below and, for each setting of the switches, remove external step attenuation until the pip peak is coincident with the PWR scale 1.0 line. Note the external attenuation remaining after each step. IF ATTENUATOR Switch Setting 01 DB 02 DB 03 DB 04 DB 05 DB 06 DB 07 DB 08 DB 09 DB	d. IF ATTENUATOR Switch Setting / Remaining External Step Attenuation 01 DB — 64.95 to 65.05 dB 02 DB — 63.90 to 64.10 dB 03 DB — 62.85 to 63.15 dB 04 DB — 61.80 to 62.20 dB 05 DB — 60.75 to 61.25 dB 06 DB — 59.70 to 60.30 dB 07 DB — 58.65 to 59.35 dB 08 DB — 57.60 to 58.40 dB 09 DB — 56.55 to 57.45 dB
7	To evaluate dispersion accuracy and linearity.	a. Adjust the signal generator for a cw output level of -45 dBm, set the IF ATTENUATOR switches to 00 DB and set the AMPLITUDE SCALE switch to LOG. Adjust the V POS screwdriver control, if necessary, to position the base of the displayed waveform coincident with the lowest graticule horizontal line. Interconnect the equipment as illustrated in figure 4-1. Adjust the test oscillator for minimum output level. Set the comb generator for 10-MHz markers and set its output level control to mid-range. Set the BANDWIDTH switch to AUTO, set the FREQ DISPERSION switch to 10 MHz/DIV and adjust the IF GAIN control to obtain a noise display one-half division high. Identify the 160-MHz	a. Display dispersion is between 95 and 105 MHz.

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
7 (Cont)		marker by means of the signal generator. After the 160-MHz marker has been located, adjust the signal generator for minimum output level and adjust the SIGNAL FREQ POSITION f_o COARSE and/or FINE control to position the 160-MHz marker at the graticule f_o vertical line. Adjust the comb generator for both 10- and 1-MHz markers and determine the display dispersion.	
		b. Determine the maximum and minimum number of markers per graticule division.	b. Display linearity is such that the maximum number of markers per division does not exceed 12 and the minimum number of markers per division is not less than eight (8).
		c. Rotate the FREQ DISPERSION VARIABLE control fully counterclockwise and note the display dispersion.	c. Display dispersion decreases to 28.5 MHz or less.
		d. Repeat step b.	d. Display dispersion decreases to 9.5 MHz or less
		e. Rotate the FREQ DISPERSION VARIABLE control fully clockwise to CAL, set the FREQ DISPERSION switch to 1 MHz/DIV and adjust the comb generator for 10-MHz markers only. Adjust the SIGNAL FREQ POSITION f_o COARSE and/or FINE control to position the 160-MHz marker at the graticule f_o vertical line and then reset the comb generator for both 10- and 1-MHz markers. Determine the display dispersion.	e. Display dispersion is between 9.5 and 10.5 MHz.
		f. Repeat step b.	f. Display dispersion decreases to 2.85 MHz or less.
		g. Rotate the FREQ DISPERSION VARIABLE control fully clockwise to CAL, set the FREQ DISPERSION switch to .3 MHz/DIV and adjust the comb generator for 10-MHz markers only. Adjust the SIGNAL FREQ POSITION f_o COARSE and/or FINE control to position the 160-MHz marker at the graticule f_o vertical line. Tune the test oscillator to 300 kHz and increase its output level until sidebands appear. Adjust the test oscillator frequency to determine the display dispersion.	g. Display dispersion is between 2.85 and 3.15 MHz.
		h. Rotate the FREQ DISPERSION VARIABLE control fully counterclockwise and adjust the test oscillator frequency to determine the display dispersion.	h. Display dispersion is 950 kHz or less.
		i. Rotate the FREQ DISPERSION VARIABLE control fully clockwise to CAL, tune the test oscillator to 100 kHz and adjust for minimum output level. Set the FREQ DISPERSION switch to .1 MHz/DIV and adjust the SIGNAL	i. Display dispersion is between 950 and 1050 kHz.

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
7 (Cont)		FREQ POSITION f_0 COARSE and/or FINE control to position the 160-MHz marker at the graticule f_0 vertical line. Increase the test oscillator output level until sidebands appear and then adjust the test oscillator frequency to determine the display dispersion.	
		j. Repeat step h.	j. Display dispersion is 285 kHz or less.
		k. Rotate the FREQ DISPERSION VARIABLE control fully clockwise to CAL, tune the test oscillator to 30 kHz and adjust for minimum output level. Set the FREQ DISPERSION switch to 30 kHz/DIV and adjust the SIGNAL FREQ POSITION f_0 COARSE and/or FINE control to position the 160-MHz marker at the graticule f_0 vertical line. Increase the test oscillator output level until sidebands appear. Adjust the test oscillator frequency to determine the display dispersion.	k. Display dispersion is between 285 and 315 kHz.
		l. Repeat step h.	l. Display dispersion is 95 kHz or less.
		m. Rotate the FREQ DISPERSION VARIABLE control fully clockwise to CAL, tune the test oscillator to 10 kHz and adjust for minimum output level. Set the FREQ DISPERSION switch to 10 kHz/DIV and adjust the SIGNAL FREQ POSITION f_0 COARSE and/or FINE control to position the 160-MHz marker at the graticule f_0 vertical line. Increase the test oscillator output level until sidebands appear. Adjust the test oscillator frequency to determine the display dispersion.	m. Display dispersion is between 95 and 105 kHz.
		n. Repeat step h.	n. Display dispersion is 28.5 kHz or less.
		o. Rotate the FREQ DISPERSION VARIABLE switch fully clockwise to CAL, tune the test oscillator to 3 kHz and adjust for minimum output level. Set the FREQ DISPERSION switch to 3 kHz/DIV and adjust the SIGNAL FREQ POSITION f_0 COARSE and/or FINE control to position the 160-MHz marker at the graticule f_0 vertical line. Increase the test oscillator output level until sidebands appear. Adjust the test oscillator frequency to determine the display dispersion.	o. Display dispersion is between 28.5 and 31.5 kHz.
		p. Repeat step h.	p. Display dispersion is 9.5 kHz or less.
		q. Rotate the FREQ DISPERSION VARIABLE control fully clockwise to CAL, tune the test oscillator to 1 kHz and adjust for minimum output level. Set the FREQ DISPERSION switch to 1 kHz/DIV and adjust the SIGNAL FREQ POSITION f_0 COARSE and/or FINE	q. Display dispersion is between 9.5 and 10.5 kHz.

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
7 (Cont)		control to position the 160-MHz marker at the graticule f_0 vertical line. Increase the test oscillator output level until sidebands appear. Adjust the test oscillator frequency to determine the display dispersion.	
		r. Repeat step h.	r. Display dispersion is 2.85 kHz or less.
		s. Rotate the FREQ DISPERSION VARIABLE control fully clockwise to CAL, set the FREQ DISPERSION switch to 0 and note the display.	s. Display has constant amplitude across the screen.
8	To evaluate narrow-band incidental fm.	Set the FREQ DISPERSION switch to 1 kHz/DIV and adjust the test oscillator for minimum output level. Adjust the SIGNAL FREQ POSITION f_0 FINE control to position the 160-MHz marker at the graticule f_0 vertical line. Set the SWEEP switch to 1000 μS/DIV and note the horizontal variation of marker pip position.	t. Maximum horizontal variation of pip position is 1/3 division (maximum incidental fm of 300 Hz).
9	To evaluate response flatness.	a. Disconnect the equipment from the setup of figure 4-1. Set the SWEEP switch to 3 MS/DIV, set the BANDWIDTH switch to 1000, set the IF ATTENUATOR switches to 40 DB, rotate the IF GAIN control fully counterclockwise, set the FREQ DISPERSION switch to 10 MHz/DIV and set the AMPLITUDE SCALE switch to LIN. Adjust the V POS screwdriver control, if necessary, to position the base of the displayed waveform coincident with the lowest graticule horizontal line.	
		b. Connect an HP608C Signal Generator (tuned to 160 MHz and adjusted for a cw output of -45 dBm) to the rear panel IF INPUT connector and adjust the SIGNAL FREQ POSITION f_0 COARSE and/or FINE controls to position the pip peak at the graticule f_0 vertical line. Adjust the IF GAIN control to position the pip peak coincident with the LIN scale 1.0 line. Tune the signal generator ±50 MHz about 160 MHz (while maintaining its output level constant at -45 dBm) and note the frequencies at which the maximum and minimum responses occur. Tune the signal generator to the frequency at which the maximum response occurs and adjust the IF GAIN control to position the pip peak coincident with the LIN scale 1.0 line. Tune the signal generator to the frequency at which the minimum response occurs and increase the signal generator output level to position the pip peak coincident with the LIN scale 1.0 line. Note the signal generator output level.	b. Signal generator output does not exceed -43 dBm.
10	To evaluate accuracy of internal markers.	a. Disconnect the signal generator from the rear panel IF INPUT connector. Set the IF ATTENUATOR switches to 00 DB, set the AMPLITUDE SCALE switch to LOG, set the BANDWIDTH switch to VAR, set the FREQ DISPERSION switch to .3 MHz/DIV and adjust the V POS	

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
10 (Cont)		screwdriver control, if necessary, to position the trace coincident with the lowest graticule horizontal line. Adjust the IF GAIN control to obtain a noise display one box high. Connect the equipment as illustrated in figure 4-1, with the test oscillator and comb generator set for minimum output level. Set the comb generator for 10-MHz markers and adjust for maximum output level. Identify the 160-MHz marker (using the signal generator) and position this signal at the graticule f_o vertical line using the SIGNAL FREQ POSITION f_o COARSE and/or FINE control. Set the signal generator for minimum output level and rotate the MARKER LEVEL control fully clockwise.	
		b. Adjust the BANDWIDTH VARIABLE control and/or FREQ DISPERSION switch, as required, until separation of the two pips is clearly defined. Tune the test oscillator to 50 kHz and increase its output level until sidebands appear about the comb generator 160-MHz marker. Adjust the test oscillator frequency until one of the sidebands coincides with the internal marker pip. Note both the test oscillator frequency (f_1) and which side band (left or right) of the comb generator marker zero-beats with the internal marker.	b. $f_1 \leq 250$ kHz
		c. Set the FREQ DISPERSION switch to 1 MHz/DIV and set the FREQ DISPERSION VARIABLE control fully counterclockwise. Carefully rotate the SIGNAL FREQ POSITION f_o COARSE control clockwise to position the next comb generator marker at the graticule f_o vertical line. Set the MARKER MODULATION switch to 10 MHz and note on which side (left or right) of the comb generator marker the internal 10-MHz marker appears. Adjust the test oscillator frequency to obtain a zero-beat between the comb generator sideband and the internal 10-MHz marker. Note the test oscillator frequency (f_2).	c. $f_1 + f_2 \leq 100$ kHz if on opposite sides; $\lvert f_1 - f_2 \rvert \leq 100$ kHz if on same side.
		d. Connect the equipment as illustrated in figure 4-2, with the test oscillator tuned to 400 kHz and adjusted for minimum output level and the signal generator tuned to 160 MHz and adjusted for minimum output level. Set the FREQ DISPERSION switch to .3 MHz/DIV, rotate the FREQ DISPERSION VARIABLE control fully clockwise to CAL, set the MARKER MODULATION switch to OFF and adjust the SIGNAL FREQ POSITION f_o COARSE and/or FINE control to position the internal marker at the graticule f_o vertical line. Increase the signal generator output level so that its amplitude is equal to that of the internal marker. Carefully adjust the signal generator frequency until a zero-beat with the internal marker is displayed. (During the remainder of this step	d. Test oscillator frequency is 500 ± 5 kHz.

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
10 (Cont)		it may be necessary to readjust the signal generator frequency to maintain a zero-beat with the internal marker.) Set the signal generator for external amplitude modulation. Set the MARKER MODULATION switch to 1 MHz; a marker will appear on each side of the center frequency marker. Increase the test oscillator output level to obtain sideband products. Adjust the test oscillator frequency so that the second sideband zero-beats with the 1-MHz marker. Note the test oscillator frequency.	
11	To evaluate external marker operation	Set the BANDWIDTH switch to AUTO, set the FREQ DISPERSION switch to 1 MHz/DIV, set the FREQ DISPERSION VARIABLE control fully clockwise to CAL, set the SWEEP switch to 10 MS/DIV and set the MARKER MODULATION switch to EXT. Connect an HP 651B Test Oscillator, tuned to 1 MHz and adjusted for minimum output level, as illustrated in figure 4-3. Increase the test oscillator output level to obtain markers.	1-MHz markers displayed.
12	To evaluate i-f bandwidth.	a. Disconnect the equipment from the setup of figure 4-3. Set the MARKER MODULATION switch to OFF, set the AMPLITUDE SCALE switch to LIN and set the IF GAIN control fully counterclockwise. Set the FREQ DISPERSION switch to 1 kHz/DIV and, if necessary, adjust the V POS screwdriver control to position the trace on the lowest graticule horizontal line. Adjust the SIGNAL FREQ POSITION f_o COARSE and/or FINE control to position the marker at the graticule f_o vertical line. Set the BANDWIDTH switch to 1 kHz and adjust the MARKER LEVEL and/or IF GAIN control to obtain a pip peak coincident with the LIN scale 1.0 line. Note the width of the displayed pip at the LIN scale 0.7 point.	a. Pip width is 1 division wide, nominal.
		b. Set the BANDWIDTH switch to 3 kHz and adjust the MARKER LEVEL control to obtain a pip peak coincident with the LIN scale 1.0 line. Note the width of the displayed pip at the LIN scale 0.7 point.	b. Pip width is 3 divisions wide, nominal.
		c. Repeat step b for BANDWIDTH switch and FREQ DISPERSION switch settings listed below. BANDWIDTH Switch Setting / FREQ DISPERSION Switch Setting 10 kHz — 3 kHz/DIV 30 kHz — 10 kHz/DIV 100 kHz — 30 kHz/DIV 1000 kHz — .3 MHz/DIV	c. Nominal pip width is: 3-1/3 divisions wide 3 divisions wide 3-1/3 divisions wide 3-1/3 divisions wide

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
12 (Cont)		d. Set the BANDWIDTH switch to VAR, rotate the BANDWIDTH VARIABLE control fully clockwise, set the FREQ DISPERSION switch to 30 kHz/DIV and adjust the MARKER LEVEL and/or IF GAIN control to obtain a pip peak coincident with the LIN scale 1.0 line. Note the width of the display at the LIN scale 0.7 point.	d. Pip width is 3-1/3 divisions wide, nominal.
		e. Rotate the BANDWIDTH VARIABLE control counterclockwise and observe the effect on the display.	e. Pip width decreases.
13	To evaluate automatic optimum bandwidth selection.	Set the BANDWIDTH switch to AUTO, rotate the the BANDWIDTH VARIABLE control fully clockwise, set the FREQ DISPERSION switch to 1 kHz and adjust the MARKER LEVEL and/or IF GAIN control to obtain a pip peak coincident with the LIN scale 1.0 line. Note the width of the display at the LIN scale 0.7 point. Rotate the FREQ DISPERSION switch clockwise, in one-step increments (while maintaining the marker pip peak coincident with the LIN scale 1.0 line) and observe the effect on the width of the display at the LIN scale 0.7 point.	Width of pip decreases (except when switching dispersions between 10 kHz/DIV and 30 kHz/DIV, between .1 MHz/DIV and .3 MHz/DIV and between 1 MHz/DIV and 3 MHz/DIV.
14	To evaluate video filtering.	a. Rotate the MARKER LEVEL control fully counterclockwise to OFF, set the BANDWIDTH switch to 100 kHz, set the AMPLITUDE SCALE switch to LOG, set the BANDWIDTH VARIABLE control fully clockwise and adjust the IF GAIN control to obtain a noise display one box high.	
		b. Rotate the BANDWIDTH VARIABLE control slowly clockwise and note the effect on the display.	b. Noise display is smoothed.
15	To evaluate sweep speeds.	a. Connect the equipment as illustrated in figure 4-4. Adjust the attenuators for 0-dB insertion. Set the time-mark generator for pulses at a 10-microsecond interval. Set the SWEEP switch to 10 uS/DIV, set the SWEEP/SYNC switch to INT SYNC (red), set the BANDWIDTH switch to 100 kHz and rotate the IF GAIN control fully counterclockwise. Determine the time for one sweep.	a. Sweep time is nominally 100 microseconds.
		b. Rotate the SWEEP VARIABLE control fully counterclockwise and determine the time for one sweep.	b. Sweep time is nominally 300 microseconds.
		c. Set the SWEEP VARIABLE control fully cloclwise to CAL, set the SWEEP switch to 30 uS/DIV, set the time-mark generator for pulses at a 50-microsecond interval and determine the time for one sweep.	c. Sweep time is nominally 300 microseconds.
		d. Repeat step b.	d. Sweep time is nominally 1 millisecond.

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
15 (Cont)		e. Repeat step b for SWEEP switch setting, SWEEP VARIABLE control setting and time-mark generator pulse intervals listed below. (1) 100 uS/DIV, Fully cw (CAL), 100 us (2) 100 uS/DIV, Fully ccw, 100 us (3) 300 uS/DIV, Fully cw (CAL), 500 us (4) 300 uS/DIV, Fully ccw, 500 us (5) 1000 uS/DIV, Fully cw (CAL), 1 ms (6) 1000 uS/DIV, Fully ccw, 1 ms (7) 3 MS/DIV, Fully cw (CAL), 5 ms (8) 3 MS/DIV, Fully ccw, 5 ms (9) 10 MS/DIV, Fully cw (CAL), 10 ms (10) 10 MS/DIV, Fully ccw, 10 ms (11) 30 MS/DIV, Fully cw (CAL), 50 ms (12) 30 MS/DIV, Fully ccw, 50 ms (13) 100 MS/DIV, Fully cw (CAL), 100 ms (14) 100 MS/DIV, Fully ccw, 100 ms (15) 300 MS/DIV, Fully cw (CAL), 500 ms (16) 300 MS/DIV, Fully ccw, 500 ms (17) 1000 MS/DIV, Fully cw (CAL), 1 second (18) 1000 MS/DIV, Fully ccw, 1 second (SWEEP Switch Setting; SWEEP VARIABLE Control Setting; Pulse Interval)	e. Nominal sweep times are: (1) 1 millisecond (2) 3 milliseconds (minimum) (3) 3 milliseconds (4) 10 milliseconds (minimum) (5) 10 milliseconds (6) 30 milliseconds (minimum) (7) 30 milliseconds (8) 100 milliseconds (minimum) (9) 100 milliseconds (10) 300 milliseconds (minimum) (11) 300 milliseconds (12) 1 second (minimum) (13) 1 second (14) 3 seconds (minimum) (15) 3 seconds (16) 10 seconds (minimum) (17) 10 seconds (18) 30 seconds (minimum)
16	To evaluate external synchronization.	a. Rotate the SWEEP VARIABLE control fully clockwise to CAL, set the SWEEP switch to 3 MS/DIV and set the SWEEP/SYNC switch to EXT SYNC (red). Adjust the time-mark generator for markers every 5 milliseconds and triggers every 10 milliseconds. b. Insert attenuation until the sweep ceases. Determine the trigger pulse amplitude from the oscilloscope display.	b. Trigger pulse amplitude is +3 volts or less.
17	To evaluate line synchronization.	Tune an HP 651B Test Oscillator to line frequency (60 Hz) and adjust for minimum output level. Connect the equipment as illustrated in figure 4-5 and set the SWEEP/SYNC switch to LINE USE. Fine tune the test oscillator to obtain a stable display and note the test oscillator frequency.	Display is synchronized to line frequency.
18	To evaluate external sweep operation.	Adjust the test oscillator for minimum output level and connect the equipment as illustrated in figure 4-6. Set the SWEEP/SYNC switch to EXT SWEEP and increase the test oscillator output level until the baseline occupies the full calibrated width of the graticule. Determine the test oscillator output level.	Test oscillator output level is 10 volts peak-to-peak (nominal).
19	To evaluate manual sweep operation.	a. Set the SWEEP/SYNC switch to MANUAL SWEEP and rotate the MANUAL control fully counterclockwise. Note the position of the spot on the screen.	a. Spot appears at left-hand side of screen.

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
19 (Cont)		b. Rotate the MANUAL control clockwise and observe the effect on the spot.	b. Spot moves to right as MANUAL control is rotated clockwise. Spot is blanked beyond extreme right-hand vertical graticule line.
20	To evaluate single sweep operation.	Set the SWEEP/SYNC switch to SINGLE SWEEP and momentarily depress the SINGLE pushbutton switch.	Single sweep is obtained.
21	To evaluate auxiliary horizontal and vertical outputs.	a. Connect the equipment as illustrated in figure 4-7. Set the SWEEP/SYNC switch to INT SWEEP, set the SWEEP TIME switch to 30 MS/DIV, set the AMPLITUDE SCALE switch to LIN and rotate the IF GAIN control fully counterclockwise. Adjust the MARKER LEVEL control (and IF GAIN control, if necessary) to obtain a pip peak coincident with the LOG scale 0 DB line. b. Determine the horizontal output voltage. c. Determine the vertical output voltage.	 b. Horizontal output voltage varies between -0.5 and +0.5 volts (nominal). c. Vertical output voltage varies between 0 and +1 volt (nominal).
22	To evaluate predetected 60-MHz output.	a. Tune an HP 608C Signal Generator to 160 MHz and adjust for minimum output level. Connect the equipment as illustrated in figure 4-8. Set the AMPLITUDE SCALE switch to LOG, set the FREQ DISPERSION switch to 0 and rotate the IF GAIN control fully counterclockwise. Increase the signal generator output level to -45 dBm and carefully trim its frequency to obtain a maximum baseline rise. b. Note the amplitude of the oscilloscope display. c. Carefully decrease the signal generator frequency (while maintaining its output level constant) until the oscilloscope display drops off 3 dB. Note the signal generator frequency. Carefully increase the signal generator frequency (while maintaining its output level constant) until the oscilloscope again drops off 3-dB after first passing through a maximum. Note the signal generator frequency.	 c. Bandwidth of predetected 60-MHz output signal is 5 MHz (nominal).
23	To evaluate intensifier operation.	a. Disconnect the equipment from the setup of figure 4-8. Set the FREQ DISPERSION switch to .1 MHz/DIV, set the BANDWIDTH switch to AUTO, set the AMPLITUDE SCALE switch to LIN and adjust the IF GAIN control to obtain a noise display one box high. Rotate the MARKER LEVEL control clockwise from its OFF position to obtain a pip peak coincident with the LIN scale 1.0 line.	

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
23 (Cont)		b. Rotate the INTENSIFIER control clockwise and note the effect on the display.	b. Bottom portion of display is clipped as INTENSIFIER control is rotated clockwise.

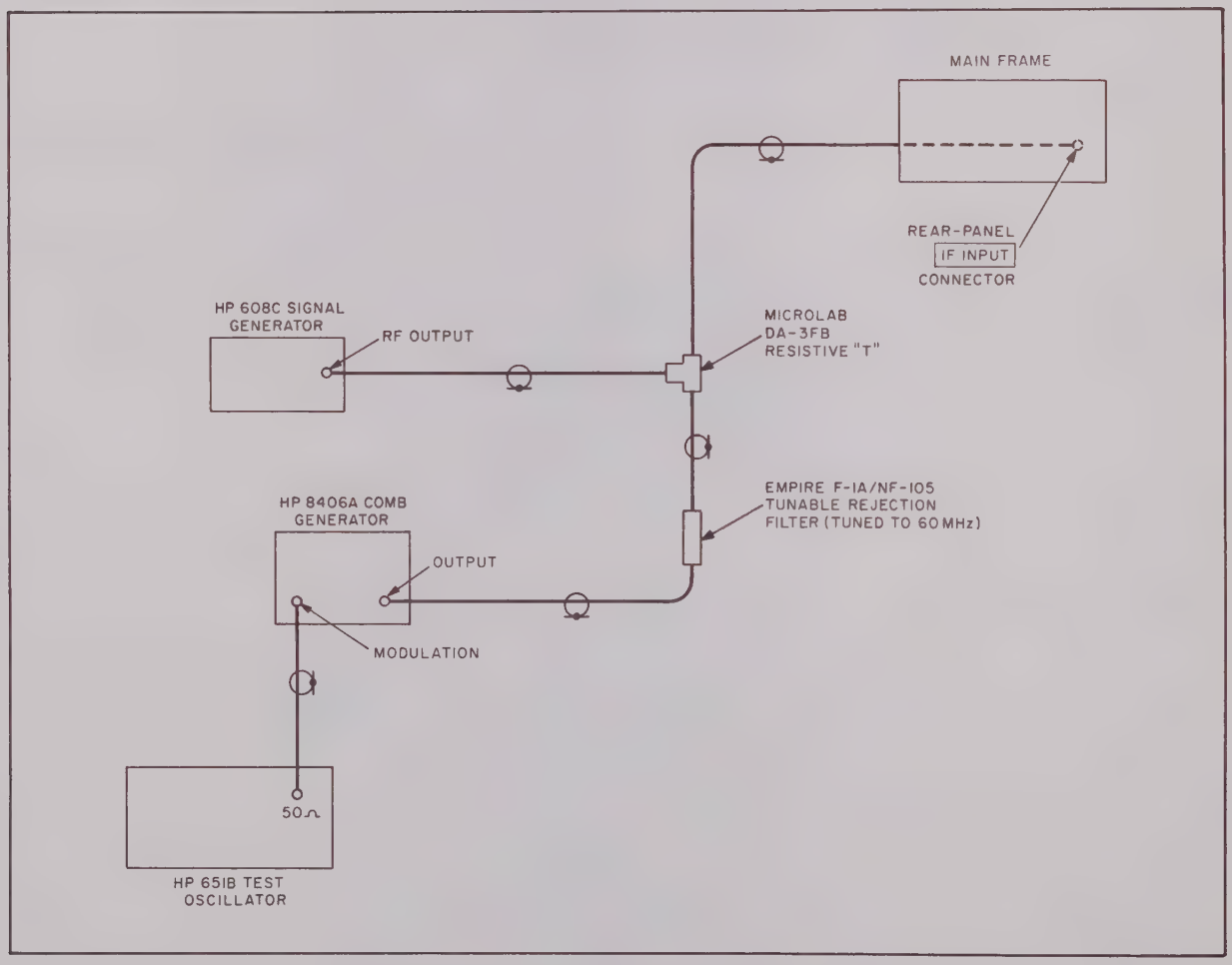


Figure 4-1. Dispersion Check Test Setup

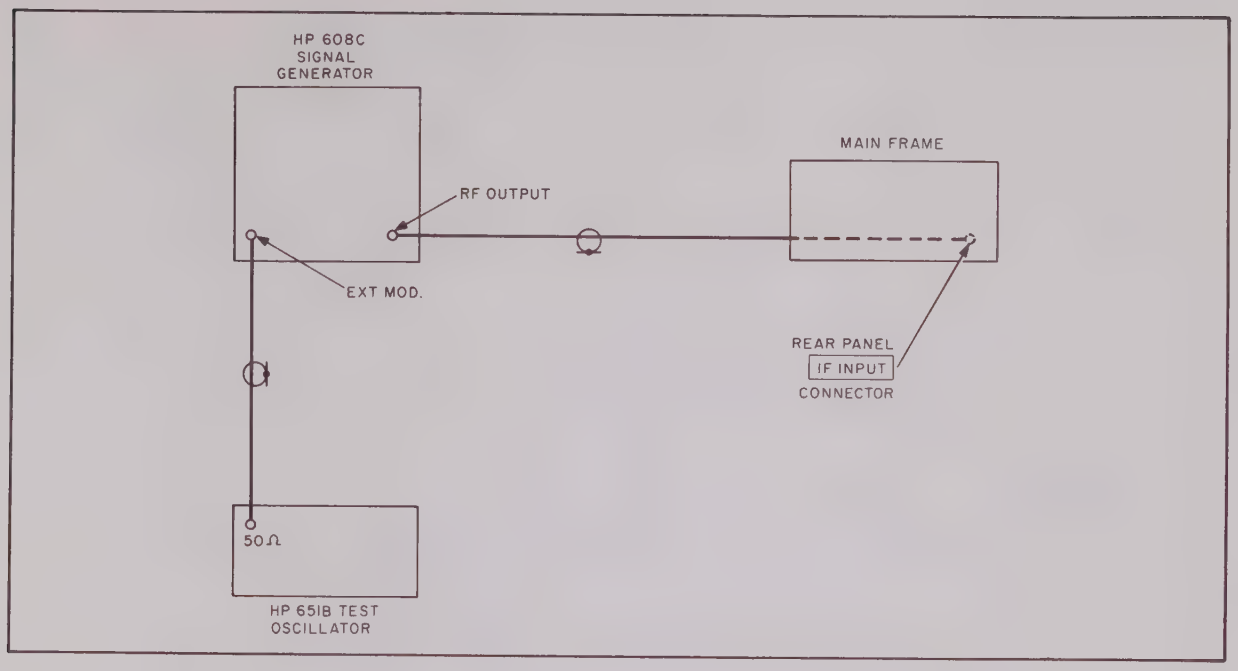


Figure 4-2. Marker Check Test Setup

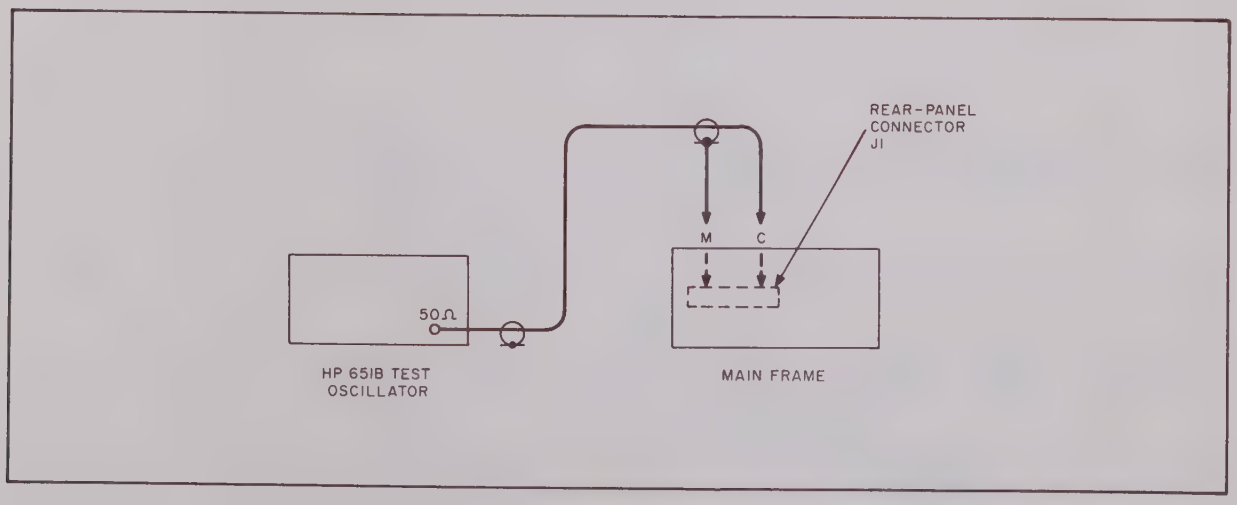


Figure 4-3. External Marker Modulation Check Test Setup

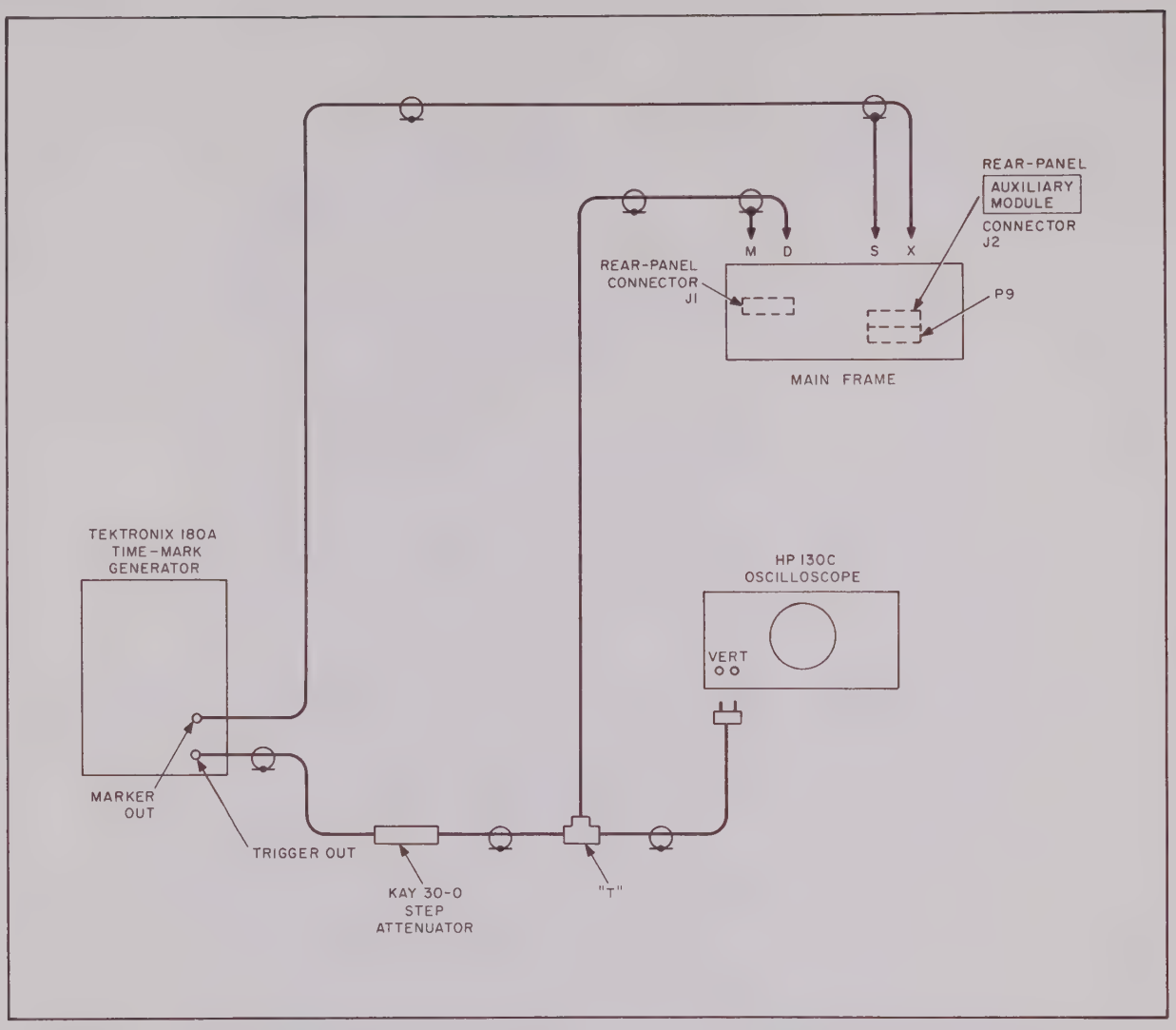


Figure 4-4. Sweep Speed Check Test Setup

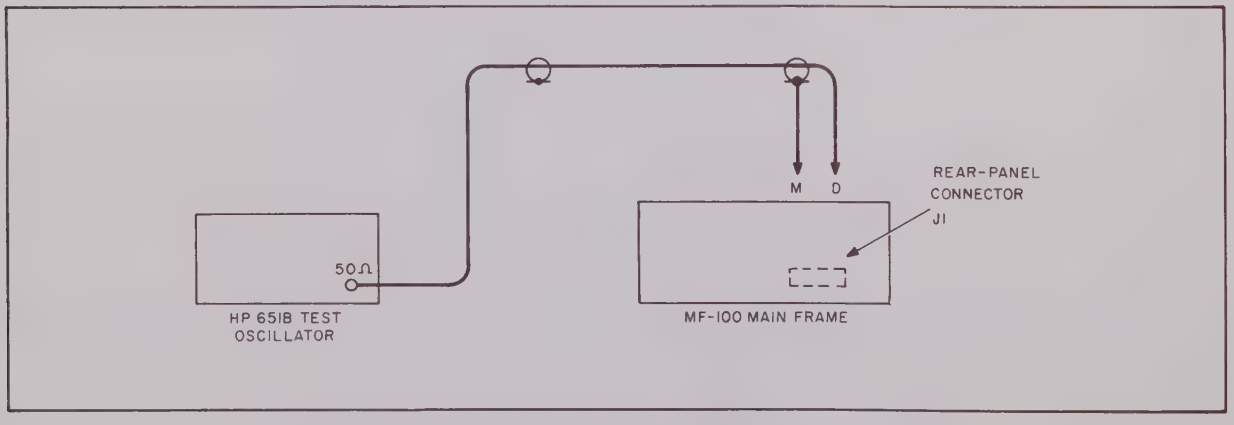


Figure 4-5. Line Synchronization Check Test Setup

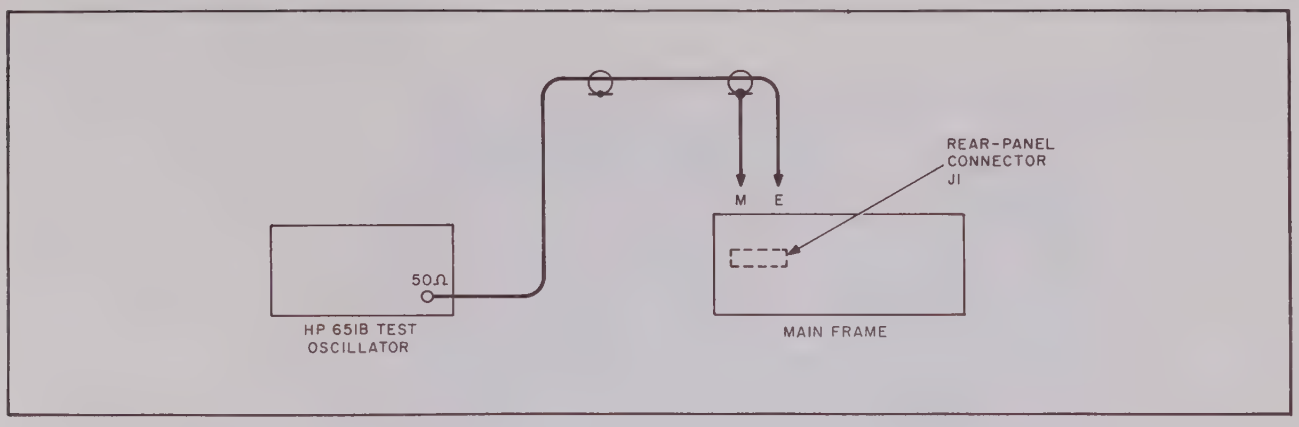


Figure 4-6. External Sweep Check Test Setup

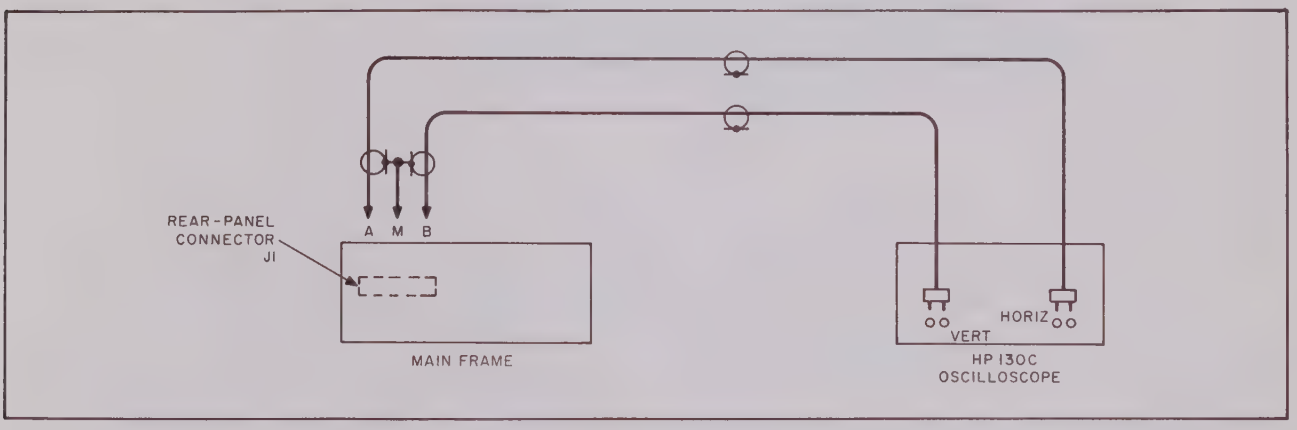


Figure 4-7. Auxiliary Horizontal and Vertical Output Check Test Setup

4-7. COMPONENT LOCATIONS.

4-8. The location of the major assemblies within the Main Frame are illustrated in figures 4-9 and 4-10. To gain access to these assemblies, remove the top and bottom dust covers as directed in paragraphs 4-9 and 4-10, respectively. To gain access to the printed circuit boards within the front and back i-f assemblies, proceed as directed in paragraph 4-11 and 4-12, respectively.

4-9. To remove the top dust cover from the Main Frame, remove the four screws (and associated hardware) that secures each side of the wraparound cover to the equipment and then carefully lift the cover away.

4-10. To remove the bottom dust cover, place the Main Frame upside-down, remove the 12 screws (and associated hardware) that secures the dust cover to the equipment and carefully lift the dust cover away.

4-11. To gain access to the printed circuit boards within front i-f assembly A2, proceed as directed in the following steps.

a. Remove the bottom dust cover as directed in paragraph 4-10.

b. Remove the 14 screws (and associated hardware) that secure the cover plate to the front i-f assembly casting.

c. Remove the cover plate; the printed circuit boards will now be visible and accessible. Refer to paragraph 4-13.

4-12. To gain access to the printed circuit boards within back i-f assembly A3, proceed as directed in the following steps.

a. Remove the top and bottom dust covers as directed in paragraphs 4-9 and 4-10, respectively.

b. Rest the Main Frame on its left side and disconnect the coaxial cables from their mating receptacles (three on the front i-f assembly and four on the back i-f assembly). Disconnect the two multipin power connectors.

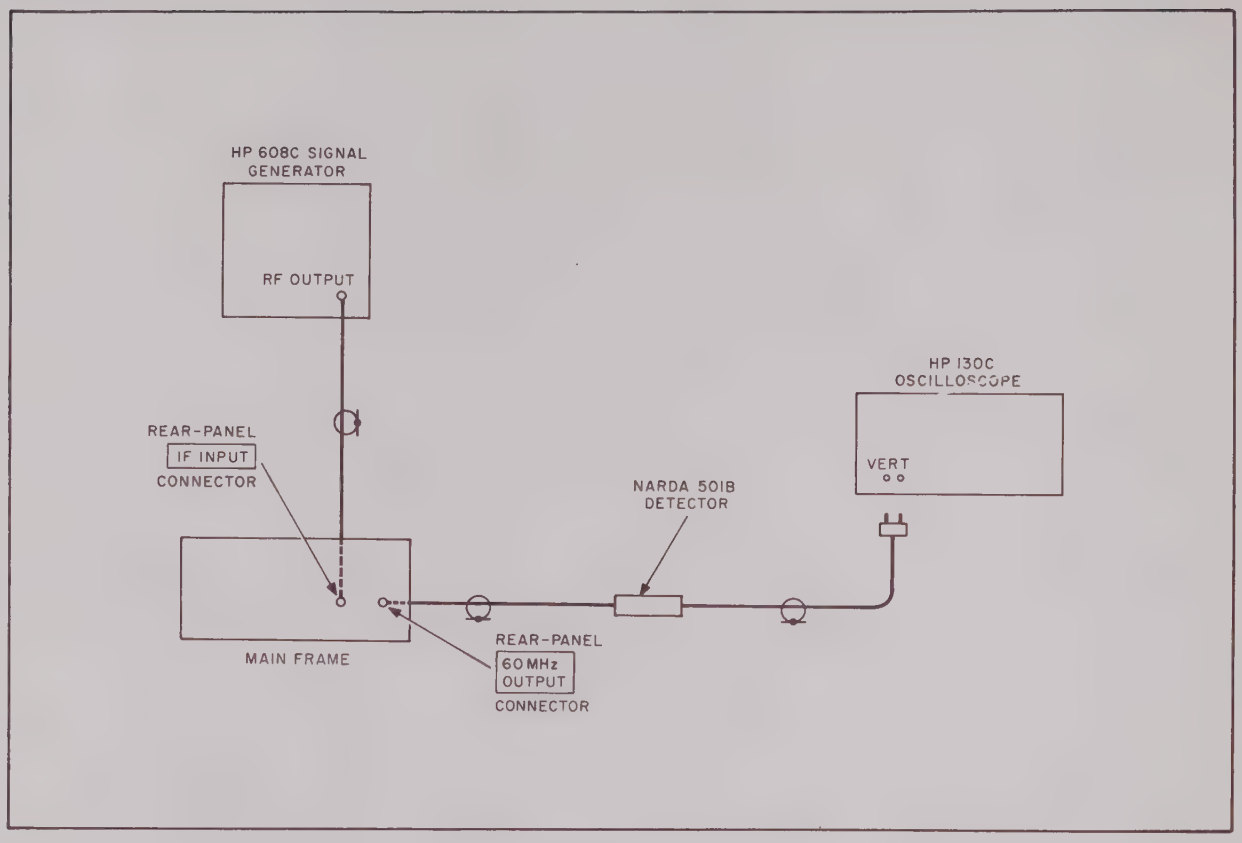


Figure 4-8. Predetected 60-MHz Output Check Test Setup

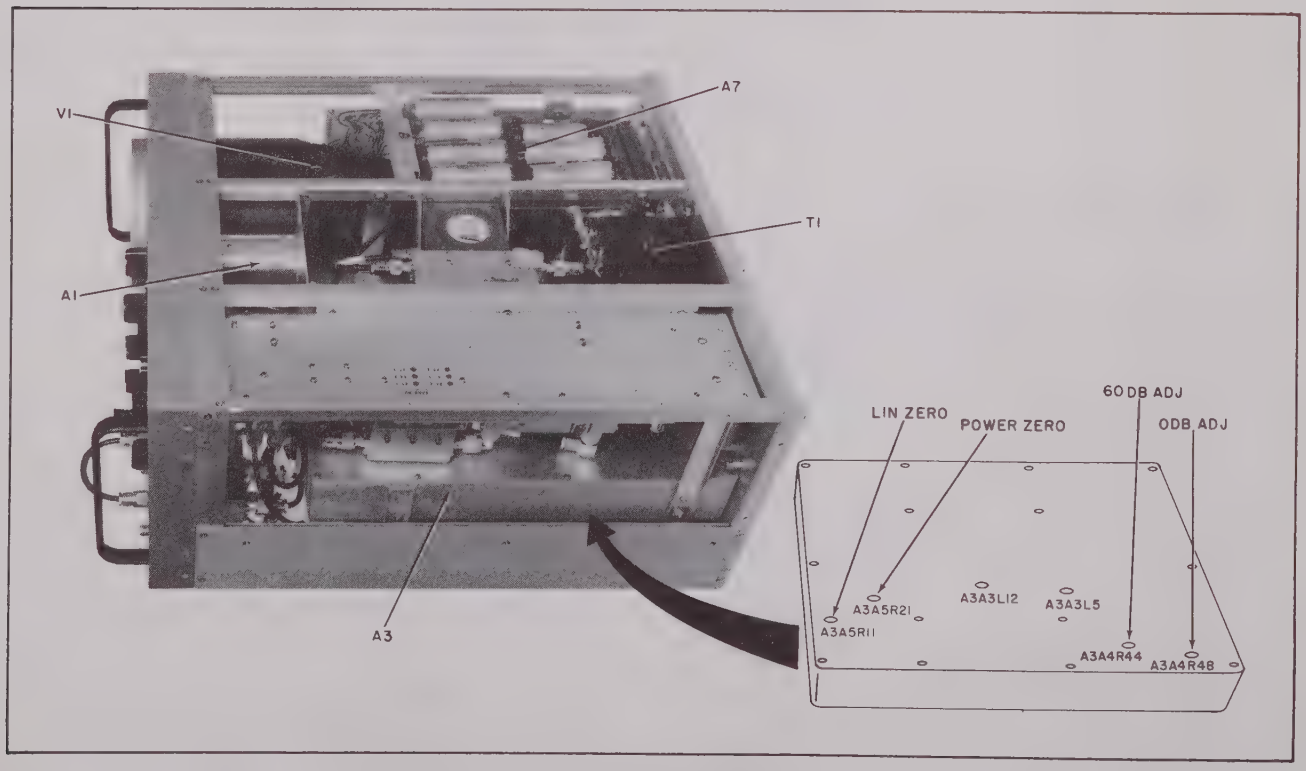


Figure 4-9. Main Frame, Top-right View

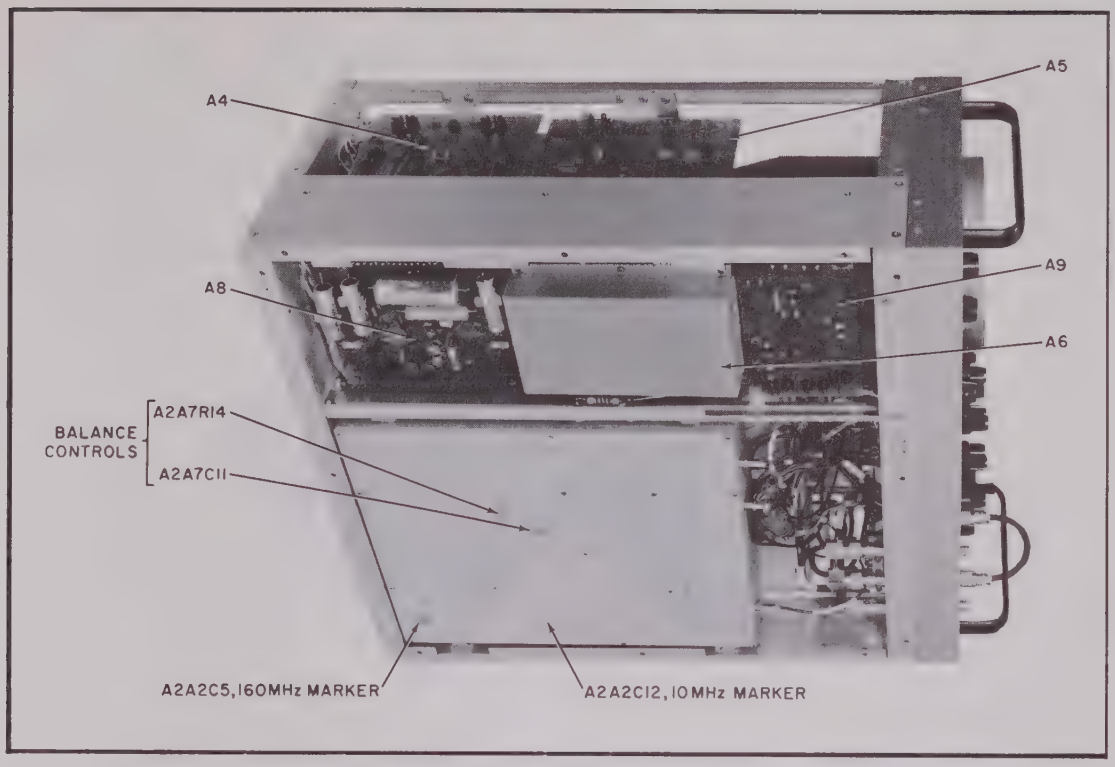


Figure 4-10. Main Frame, Bottom-left View

c. Rest the Main Frame rightside-up and remove the two bolts (and associated hardware) that secures the back i-f casting to the rear panel.

d. Turn the Main Frame upside-down and remove the four screws (and associated hardware) that secure the mounting brackets to the equipment frame.

e. Carefully place the Main Frame rightside-up and remove the three screws (and associated hardware) that secure the mounting brackets to the equipment frame.

f. Carefully lift the Main Frame up and away from the i-f assemblies. Place the Main Frame adjacent to the castings.

g. Remove the 15 screws (and associated hardware) that secure the cover plate to the back i-f assembly casting.

h. Remove the cover plate; the printed circuit boards will now be visible and accessible. Refer to paragraph 4-13.

Note

It is not necessary to separate the back and front i-f assemblies for alignment, repair and/or replacement of a printed circuit board. These assemblies should be separated only when repairing power supply wiring.

i. Place the castings on the Main Frame (see figure 4-11) and connect all coaxial and power connectors to their mating receptacles.

4-13. To gain access to the underside of any printed circuit board on either the front or back i-f assembly, proceed as directed in the following steps.

a. Disconnect all coaxial connectors from the printed circuit board to be removed.

b. Remove the four or six screws (and associated hardware) that secure the printed circuit board to the casting.

c. Carefully lift the board until the multipin connector or connectors on the underside of the board are accessible. Carefully disengage the connector(s), observing utmost care not to rotate them through 180-degrees.

4-14. POWER SUPPLY TROUBLE LOCALIZATION.

4-15. Improper operation of the Main Frame may be due to a malfunction within the power supplies. To ascertain that these supplies are operating properly, or to localize a malfunction, proceed as directed in table 4-4.

WARNING

Voltages dangerous to human life exist within the Main Frame. Observe extreme caution at all times when measuring power supply voltages.

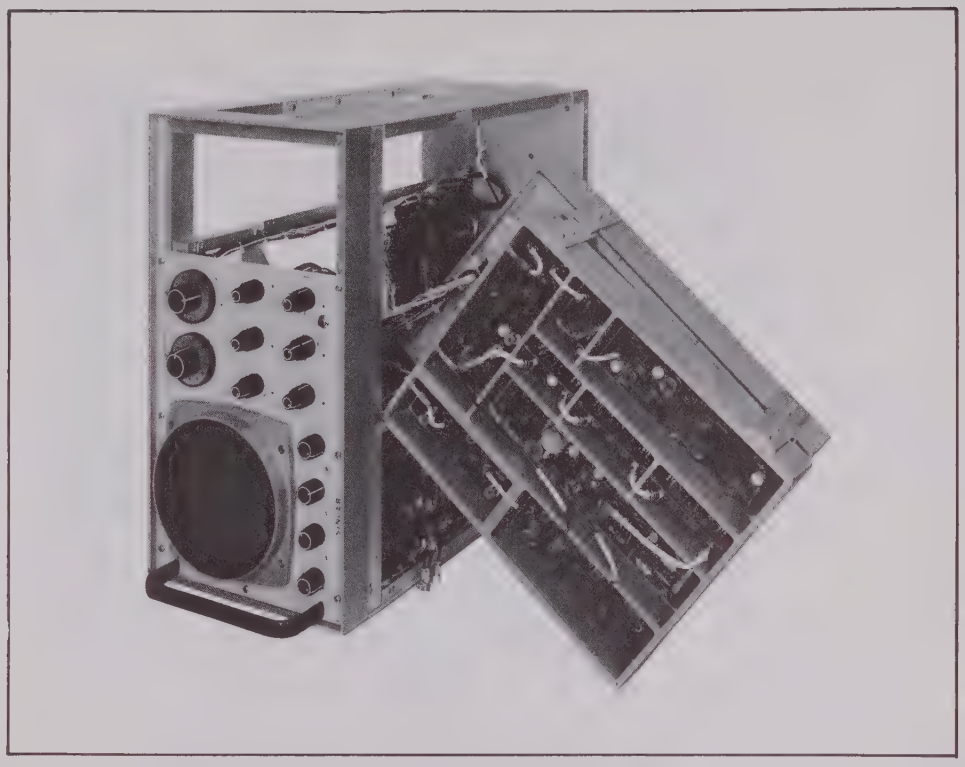


Figure 4-11. Placement of Equipment to Gain Access to Back I-f Assembly A3

TABLE 4-4. POWER SUPPLY TROUBLE LOCALIZATION PROCEDURES

Step		Procedure	Normal Indication	If Indication is Normal	If Indication is Abnormal
Major	Minor				
1		Connect the + lead of a Simpson 260 VOM (set to the +1000 VDC range) to the rear-panel +300 V test jack; connect the common lead to the rear-panel GND test jack. Note the VOM indication.	VOM indicates between +285 and +315 volts.	Proceed to major step 2.	Proceed to minor step 1.
	1	Connect the + lead of the VOM (set to the 1000 VAC range) to T1-5; connect the common lead to T1-7. Note the VOM indication.	VOM indicates 510 volts rms (nominal).	Check A7CR1, A7CR2 and associated circuitry.	Replace T1.
2		Connect the + lead of the VOM (set to the +250 VDC range) to the rear-panel +100 V test jack; connect the common lead to the rear-panel GND test jack. Note the VOM indication	VOM indicates +100 volts	Proceed to major step 3.	Adjust A8R10 to obtain a VOM indication of +100 volts. If this indication cannot be obtained by adjustment of the control, proceed to minor step 2.
	2	Check fuse A7F1.	Fuse is continuous.	Proceed to minor step 3.	Check +100 volt line for a short to ground and correct this condition. Insert a replacement fuse.

TABLE 4-4. POWER SUPPLY TROUBLE LOCALIZATION PROCEDURE (Cont'd)

Step		Procedure	Normal Indication	If Indication is Normal	If Indication is Abnormal
Major	Minor				
	3	Connect the + lead of the VOM (set to the 250 VAC range) to T1-8; connect the common lead to T1-10. Note the VOM indication.	VOM indicates 180 volts rms (nominal).	Check Q5 (see table 4-7) and A8Q1, A8Q2, A8Q3, A8Q4 (see table 4-20) and associated circuitry. Check A7CR3, A7CR4 and associated circuitry.	Replace T1.
3		Connect the + lead of the VOM (set to the +50 VDC range) to the rear-panel +12 V test jack; connect the common lead to the rear-panel GND test jack. Note the VOM indication.	VOM indicates +12 volts.	Proceed to major step 4.	Adjust A8R19 to obtain a VOM indication of +12 volts. If this indication cannot be obtained by adjustment of the control, proceed to minor step 4.
	4	Check fuse A7F2.	Fuse is continuous.	Proceed to minor step 5.	Check +12 volt line for a short to ground and correct this condition. Insert a replacement fuse.
	5	Connect the + lead of the VOM (set to the 50 VAC range) to T1-11; connect the common lead to T1-12. Note the VOM indication.	VOM indicates 15 volts rms (nominal).	Check A7CR5 through A7CR8 and associated circuitry. Check Q1 and Q2 (see table 4-7) and A8Q5, A8Q6, A8Q7 (see table 4-20) and associated circuitry.	Replace T1.
4		Connect the + lead of the VOM (set to the -50 VDC range) to the rear-panel -12 V test jack; connect the common lead to the rear-panel GND test jack. Note the VOM indication.	VOM indicates -12 volts.	Proceed to major step 5.	Adjust A8R28 to obtain a VOM indication of -12 volts. If this indication cannot be obtained by adjustment of the control, proceed to minor step 6.
	6	Check fuse A7F3.	Fuse is continuous.	Proceed to minor step 7.	Check -12 volt line for a short to ground and correct this condition. Insert a replacement fuse.
	7	Connect the + lead of the VOM (set to the 50 VAC range) to T1-13; connect the common lead to T1-14. Note the VOM indication.	VOM indicates 15 volts rms (nominal).	Check A7CR9 through A7CR12 and associated circuitry. Check Q3 and Q4 (see table 4-7) and A8Q8, A8Q9, A8Q10 (see table 4-20) and associated circuitry.	Replace T1.

TABLE 4-4. POWER SUPPLY TROUBLE LOCALIZATION PROCEDURE (Cont'd)

Step		Procedure	Normal Indication	If Indication is Normal	If Indication is Abnormal
Major	Minor				
5		Set the SWEEP/SYNC switch to MANUAL, set the MANUAL control to mid-range, set the BRIGHTNESS control fully clockwise and rotate the INTENSIFIER control fully counterclockwise. Note the CRT display.	Spot appears on screen.	Power supplies operate properly.	Rotate A9R27 fully clockwise and replace CRT power supply A6 (refer to paragraph 4-39). Adjust A9R27 as directed in steps a through c of paragraph 4-36.

4-16. TROUBLESHOOTING PROCEDURES.

4-17. A defect within the Main Frame can be located by either symptomatic or systematic troubleshooting. The symptomatic troubleshooting procedure of table 4-5 enables the operator to localize a malfunction to a particular circuit by noting if normal operation is achieved when a front panel switch is set to one or more positions but not to others. Should operation of the front panel controls fail to produce normal operation, employ the step-by-step systematic troubleshooting procedures of table 4-6 to locate the malfunction.

4-18. ALIGNMENT PROCEDURES, FRONT I-F ASSEMBLY A2.

4-19. The procedures for aligning the various printed circuit boards within front i-f assembly A2 are detailed in paragraphs 4-20 through 4-27. Refer to paragraph 4-11 for instructions on how to gain access to these boards. Set the front panel controls as listed below prior to making any adjustments to the front i-f assembly.

Control	Setting
SCALE ILLUMINATION control	Fully cw
IF ATTENUATOR switches	00 dB
FREQ DISPERSION switch	.3 MHz/DIV
FREQ DISPERSION VARIABLE control	CAL (Fully cw)
MARKER MODULATION switch	OFF
MARKER LEVEL control	OFF (Fully ccw)
AMPLITUDE SCALE switch	LOG
SIGNAL FREQ POSITION f_0 COARSE control	Mid-range
SIGNAL FREQ POSITION f_0 FINE control	Mid-range
BANDWIDTH switch	100 kHz
BANDWIDTH VARIABLE control	Fully cw
SWEEP switch	3 MS/DIV
SWEEP VARIABLE control	CAL (Fully cw)
SWEEP/SYNC switch	INT SWEEP
IF GAIN control	To obtain one division of noise

4-20. MARKER OSCILLATOR A2A1. To align the marker oscillator, set the front panel controls as listed in paragraph 4-19 and then continue as directed below.

a. Connect the equipment as illustrated in figure 4-1. Tune the signal generator for a 160-MHz cw output and set the comb generator for 10-MHz markers. Set the test oscillator for minimum output level. Adjust the comb generator output level to obtain a convenient display amplitude and identify the 160-MHz marker by means of the signal generator.

b. Center the 160-MHz marker at the graticule f_0 vertical line by means of the SIGNAL FREQ POSITION f_0 COARSE and/or FINE control and then set the signal generator for minimum output level.

TABLE 4-5. SYMPTOMATIC TROUBLESHOOTING PROCEDURE

Symptom	Probable Cause
Internal center frequency marker cannot be obtained but 160-MHz injected at rear-panel IF INPUT connnector is displayed.	Check A2A1Q1 (see table 4-8), MARKER MODULATION switch S4 and associated circuitry.
10-MHz sidebands cannot be obtained on center frequency marker but 1-MHz sidebands can be displayed.	Check A2A1Q3 (see table 4-8) and associated circuitry.
1-MHz sidebands cannot be obtained on center frequency marker but 10-MHz sidebands can be displayed.	Check A2A1Q4 (see table 4-8) and associated circuitry.
Neither 10-MHz nor 1-MHz sidebands can be obtained on center frequency marker but external marker modulation is displayed.	Check A2A1Q2 (see table 4-8) and associated circuitry.
Internal center frequency marker cannot be either internally or externally modulated.	Check A2A1CR1 through A2A1CR4 and associated circuitry.
Marker level cannot be adjusted.	Check MARKER LEVEL control R21/S8 and associated circuitry.
Horizontal trace present. No vertical display when AMPLITUDE SCALE switch set to LIN; vertical display normal in LOG and PWR.	Check A3A5Q2, A3A5Q3 (see table 4-17) and associated circuitry.
Horizontal trace present. No vertical display when AMPLITUDE SCALE switch set to PWR; vertical display normal in LIN and LOG.	Check A3A5Q4 through A3A5Q7 (see table 4-17) and associated circuitry.
Horizontal trace present. No vertical display when AMPLITUDE SCALE switch set to LOG, LIN or POWER.	Refer to table 4-6.
Horizontal trace present. No vertical display when AMPLITUDE SCALE switch set to LIN or PWR; vertical display normal in LOG.	Check A3A5Q1 (see table 4-19) and associated circuitry.
Horizontal trace present. No vertical display when BANDWIDTH switch set to 1000 kHz; vertical display present for all other settings of switch.	Check A3A1Q1 (see table 4-13), A3A1CR1, A3A1CR2, A3A3CR1, A3A3CR2 and associated circuitry.
Horizontal trace present. No vertical display when BANDWIDTH switch set to any position other than 1000 kHz.	Check A3A2 (see table 4-14), A3A3 (see table 4-15), diodes A3A1CR3 and A3A1CR4 and associated circuitry.
Horizontal trace present. No vertical display when FREQ DISPERSION switch set to 10, 3 or 1 MHz/DIV; vertical display normal for all other switch settings.	Check A2A7Q1, A2A7Q2, A2A7Q3 (see table 4-10) and associated circuitry.
Horizontal trace present. No vertical display when FREQ DISPERSION switch set to .3 MHz/DIV, .1 MHz/DIV, 10, 3, 1 or 0 kHz/DIV; vertical display normal for all other switch settings.	Check A2A7Q5, A2A7Q6, A2A7Q7 (see table 4-10) and associated circuitry.
Sweep cannot be initiated by operation of SINGLE pushbutton switch S10 when SWEEP/SYNC switch S3 is set to SINGLE, and all other sweep modes are operational.	Check the contacts of SWEEP SYNC switch S3 and SINGLE pushbutton switch S10; also check associated resistors R27 and R28, along with capacitor C4.

TABLE 4-5. SYMPTOMATIC TROUBLESHOOTING PROCEDURE (Cont'd)

Symptom	Probable Cause
Sweep cannot be initiated in the sync modes of operation, i.e., SWEEP/SYNC switch S3 is set to either CAL, USE, INT, EXT; but all other modes are operational.	Check A5Q34/Q35, A5Q36/Q37, A5Q26, A5Q27, A5Q19 (see table 4-19 and associated circuitry.
In analyzer operation only, SWEEP switch S2B set to any MS/DIV position, sweep is erratic; but in the synchroscope mode, the set is operational.	Check timing switch A5Q40 (table 4-19) and associated circuitry.
No sweep in any mode of operation except MAN and EXT.	Refer to Systematic Troubleshooting Procedure Table 4-6.
No sweep at all in any mode of operation.	Check A5Q29/Q30 (see table 4-19); A4Q10, A4Q11, A4Q12 (see table 4-18); the CRT and associated circuitry.

TABLE 4-6. SYSTEMATIC TROUBLESHOOTING PROCEDURE

Step	Procedure	Normal Indication	If Indication is Normal	If Indication is Abnormal
		Note Steps 1 through 9 provide procedures for troubleshooting the equipment when a trace is present with no vertical deflection.		
1	Set SWEEP/SYNC switch S3 to CAL	Full-scale LOG deflection of the trace on the Main Frame CRT display.	Proceed to step 2.	Check V POS potentiometer R7; a dc potential should be present on pin 12 of deflection amplifier assembly A4. Using a dc meter, check the contacts of relay K1 for continuity. If no fault is uncovered, check deflection amplifier assembly A4. Refer to table 4-18.
2	Remove plug P2 from jack J2 of back i-f assembly A3; connect a Hewlett Packard Model 606B signal generator to jack J2 of the assembly and apply a -24 dBm 6.5 MHz signal. Adjust the signal generator output frequency for maximum deflection of the trace.	Full-scale deflection of the trace on Main Frame CRT display.	Proceed to step 5.	Proceed to step 3.

TABLE 4-6. SYSTEMATIC TROUBLESHOOTING PROCEDURE (Cont'd)

Step	Procedure	Normal Indication	If Indication is Normal	If Indication is Abnormal
3	Gain access to back i-f assembly A3. Remove plug P2 from jack J1 of log amplifier assembly A3A4. Connect the signal generator to jack J1 of the assembly and apply a -10 dBm 6.5 MHz signal.	Full-scale deflection of the trace on Main Frame CRT display.	Refer to table 4-5.	Disconnect the signal generator and reconnect the cables. Proceed to step 4.
4	Remove plug P2 from jack J1 of Lin Power scale assembly A3A5. Connect the signal generator to jack J1 of the assembly and apply a +5 dBm 6.5 MHz signal.	Full-scale LIN deflection of the Main Frame CRT display.	Check log amplifier assembly A4 in accordance with table 4-16.	Refer to table 4-5 and check associated circuitry including resistor R51.
5	Restore all loosened cables of back i-f assembly A3, and gain access to the internal circuits of front i-f assembly A2 using the procedures of paragraph 4-11. Remove plug P2 from jack J1 of 60-6.5 MHz converter assembly A2A9. Connect the signal generator to jack J1 of the assembly and apply a -20 dBm 60 MHz signal. Adjust the signal generator output frequency for maximum deflection of the trace.	Full scale LOG deflection of the trace on the Main Frame CRT display.	Disconnect the signal generator and reconnect the cable to assembly A2A9.	Check 60-6.5 MHz converter assembly A2A9 in accordance with table 4-12.
6	Remove plug P2 from jack J1 of 60 MHz amplifier assembly A2A8. Connect a Hewlett Packard Model 608C to jack J1 of the assembly and apply a -40 dBm 60 MHz signal. **Note** The -40 dBm signal is nominal for normal operating conditions; if the IF GAIN is reduced to minimum, a -23 dBm signal is required. If the IF GAIN adjust is set to maximum a -53 dBm signal is required.	Full-scale LOG deflection of the trace on the Main Frame CRT display.	Disconnect the signal generator and reconnect the cable to assembly A2A8.	Check 60 MHz amplifier assembly A2A8 in accordance with table 4-11.
7	Remove plug P2 from jack J1 of wideband and narrow band swept oscillator assembly A2A7. Connect the signal generator to jack J1 of the assembly and check the sensitivity in accordance with the minimum performance tests.	The sensitivity should be better than -105 dBm.	Disconnect the signal generator and reconnect the cable to assembly A2A7.	Check wideband and narrow band swept oscillator assembly A2A7 in accordance with table 4-10.
8	Remove plug P2 from jack J1 of high pass filter assembly A2A4. Connect the signal generator to jack J1 of the assembly and check the sensitivity as in step 7.	The sensitivity should be better than -93 dBm.	Disconnect the signal generator and reconnect the cable to assembly A2A4. Perform step 9.	Check filter assemblies A2A4, A2A5 and A2A6.
9	Remove plug P2 from jack J2 of 160 MHz wideband amplifier assembly A2A3. Connect the signal generator to jack J2 of the assembly and check the sensitivity as in step 7.	The sensitivity should be better than -110 dBm.	Check i-f attenuator assembly A1.	Check 110 MHz wideband amplifier assembly A2A3 in accordance with table 4-9.

TABLE 4-6. SYSTEMATIC TROUBLESHOOTING PROCEDURE (Cont'd)

<table>
<tr><th>Step</th><th>Procedure</th><th>Normal Indication</th><th>If Indication is Normal</th><th>If Indication is Abnormal</th></tr>
<tr><td></td><td></td><td>Note
Steps 10 and 11 provide troubleshooting procedures covering the sweep control circuit.</td><td></td><td></td></tr>
<tr><td>10</td><td>With SWEEP switch S2 set to any MS/DIV position, and SWEEP SYNC switch S3 set to MAN, set MANUAL SWEEP potentiometer R26 fully counterclockwise and check the output levels of the sweep control circuitry.</td><td><table><tr><th>Stage</th><th>Output Indication</th></tr><tr><td>Q31/Q32</td><td>0</td></tr><tr><td>Q33</td><td>1</td></tr><tr><td>Q26</td><td>0</td></tr><tr><td>Q21</td><td>0</td></tr><tr><td>Q19</td><td>0</td></tr><tr><td>Q20</td><td>1</td></tr><tr><td>Q11</td><td>0*</td></tr><tr><td>Q27</td><td>0</td></tr><tr><td>Q28</td><td>0</td></tr><tr><td>Q38/Q39</td><td>1</td></tr><tr><td>Q25</td><td>0</td></tr><tr><td>Q22</td><td>0</td></tr><tr><td>Q23</td><td>1</td></tr><tr><td>Q24</td><td>0</td></tr><tr><td>Q12</td><td>1*</td></tr></table>* 1 and 0 indications for Q11 and Q12 are 12 volts and 6 volts, respectively; for all others 1 and 0 are nominally 8 volts and 0 volt.</td><td>Proceed to step 11.</td><td>Check stages in order of table, and repair stage providing faulty output indication.</td></tr>
<tr><td>11</td><td>With SWEEP switch S2 set to any MS/DIV position and SWEEP SYNC switch S3 set to MAN, adjust MANUAL SWEEP potentiometer R26 until Schmitt trigger A5Q31/Q32 trips.</td><td>A5Q31/Q32 should trip when the input potential reaches 5 volts, at which time the dot should be blanked.<table><tr><th>Stage</th><th>Output Indication</th></tr><tr><td>Q31/Q32</td><td>1</td></tr><tr><td>Q33</td><td>0</td></tr><tr><td>Q26</td><td>0</td></tr><tr><td>Q21</td><td>1</td></tr><tr><td>Q20</td><td>0</td></tr><tr><td>Q11</td><td>1*</td></tr><tr><td>Q27</td><td>0</td></tr><tr><td>Q28</td><td>1</td></tr><tr><td>Q38/Q39</td><td>0</td></tr><tr><td>Q25</td><td>1</td></tr><tr><td>Q23</td><td>0</td></tr><tr><td>Q24</td><td>1</td></tr><tr><td>Q12</td><td>0*</td></tr></table>*1 and 0 indications for Q11 and Q12 are 12 volts and 6 volts, respectively; for all others 1 and 0 are nominally 8 volts and 0 volt.</td><td></td><td>Check stages in order of table and repair stage providing faulty output indication.</td></tr>
</table>

c. Rotate the MARKER LEVEL control clockwise from its OFF position and set to obtain a convenient marker display amplitude.

d. Adjust A2A1C5 so that the internal 160-MHz marker pip zero-beats with the comb generator 160-MHz marker.

e. Turn on the comb generator 1-MHz interpolation markers and set the MARKER MODULATION switch to 1 MHz.

f. Adjust A2A1C19 so that the internal 1-MHz markers zero-beat with the comb generator 1-MHz interpolation markers.

g. Turn off the comb generator 1-MHz interpolation markers, set the FREQ DISPERSION switch to 3 MHz/DIV and set the MARKER MODULATION switch to 10 MHz.

h. Adjust A2A1C15 so that the internal 10-MHz markers zero-beat with the comb generator markers.

4-21. 160-MHz WIDEBAND AMPLIFIER A2A3. To align the 160-MHz wideband amplifier, proceed as follows.

a. Connect the equipment as illustrated in figure 4-12. The sweep generator is to be tuned to a center frequency of 160 MHz, a sweepwidth of 200 MHz and an output level of approximately -20 dBm. Set the step attenuator for 0 dB insertion.

b. Adjust A2A3C18 to position the notch at exactly 100 MHz.

c. Tune A2A3L2, A2A3L3, A2A3C17 and A2A3C2 to obtain a response which is flat (within ± 1 dB) from 110 to 210 MHz.

d. Connect the equipment as illustrated in figure 4-14 and set the step attenuator for 10 dB insertion. Note the waveform displayed on the oscilloscope screen.

e. Reset the step attenuator for 0 dB insertion and connect the 20-ft cable directly to the MF-100 rear panel 160MHz IF INPUT connector and again note the waveform; it should be no greater then that noted in step d.

4-22. HIGH PASS FILTER A2A4. To align the high pass filter, proceed as directed in the following steps.

a. Connect the equipment as illustrated in figure 4-15.

b. Tune the sweep generator to a center frequency of 160 MHz, a sweepwidth of 300 MHz and an output level of 0 dBm. Tune the signal generator to obtain a marker at 60 MHz.

c. Adjust A2A4C4 to position the notch at 60 MHz, as illustrated in figure 4-16.

4-23. LOW PASS FILTER A2A5. To align this low pass filter, proceed as directed in the following steps.

a. Connect the equipment as illustrated in figure 4-17.

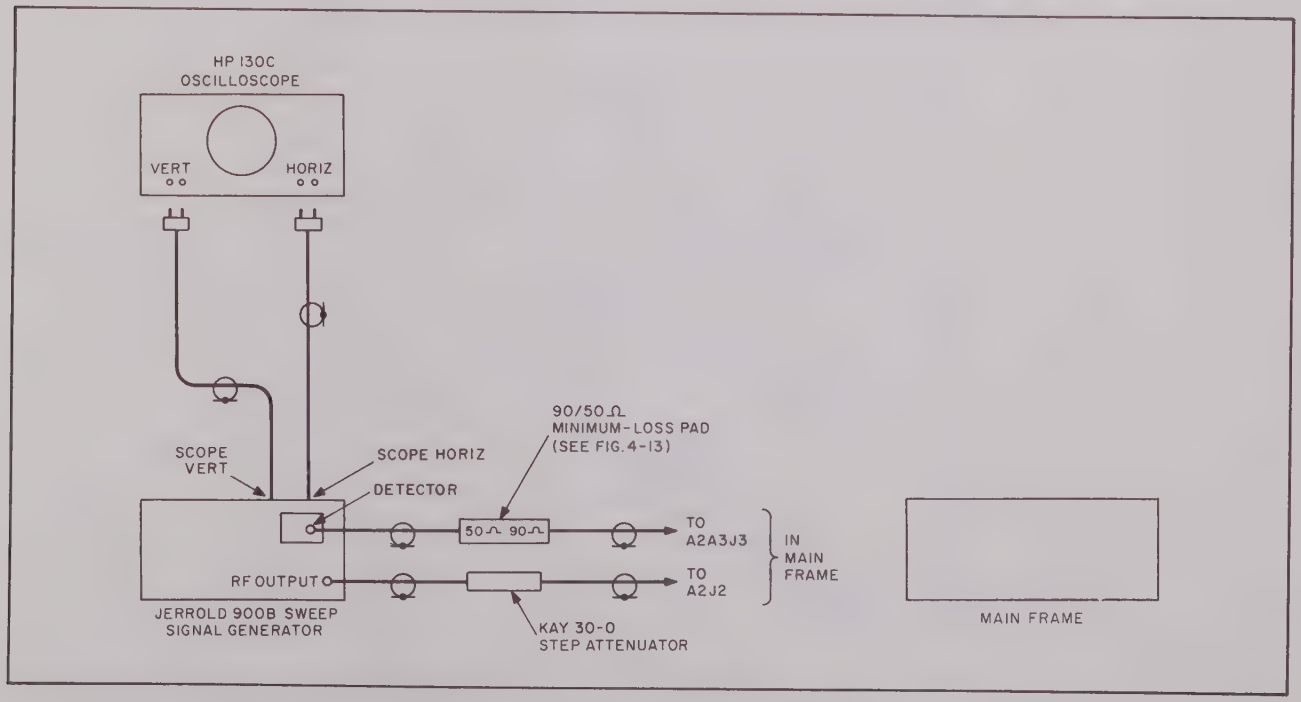


Figure 4-12. 160-MHz Wideband Amplifier A2A3 Alignment, Equipment Setup No. 1

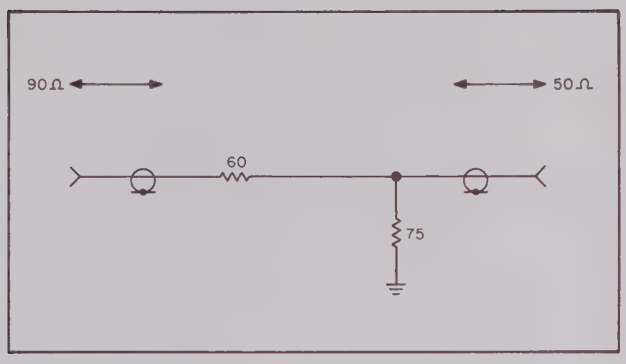


Figure 4-13. 90/50 Ohm Minimum Loss Pad, Schematic Diagram

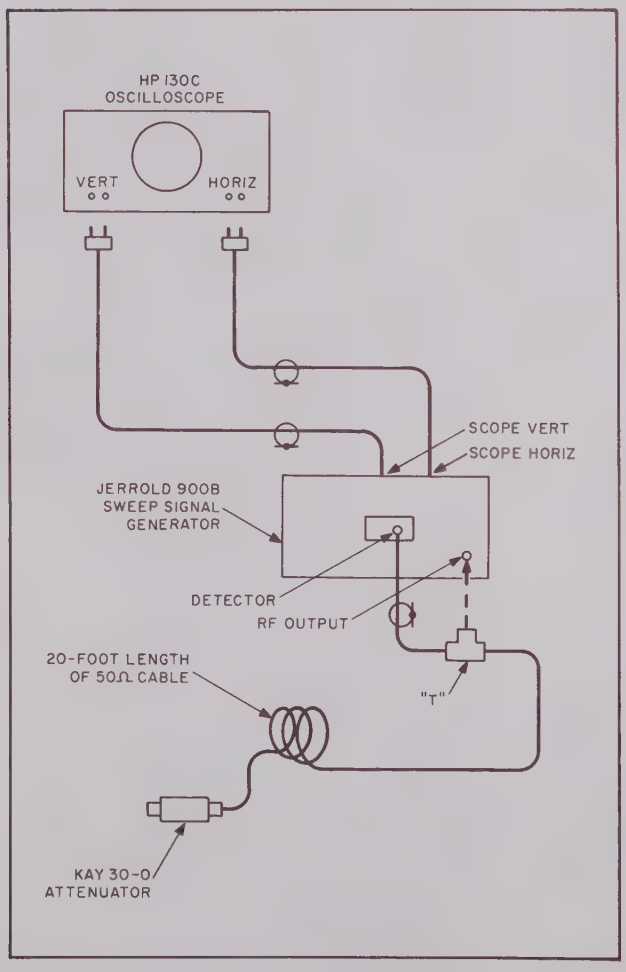


Figure 4-14. 160-MHz Wideband Amplifier A2A3 Alignment, Equipment Setup No. 2

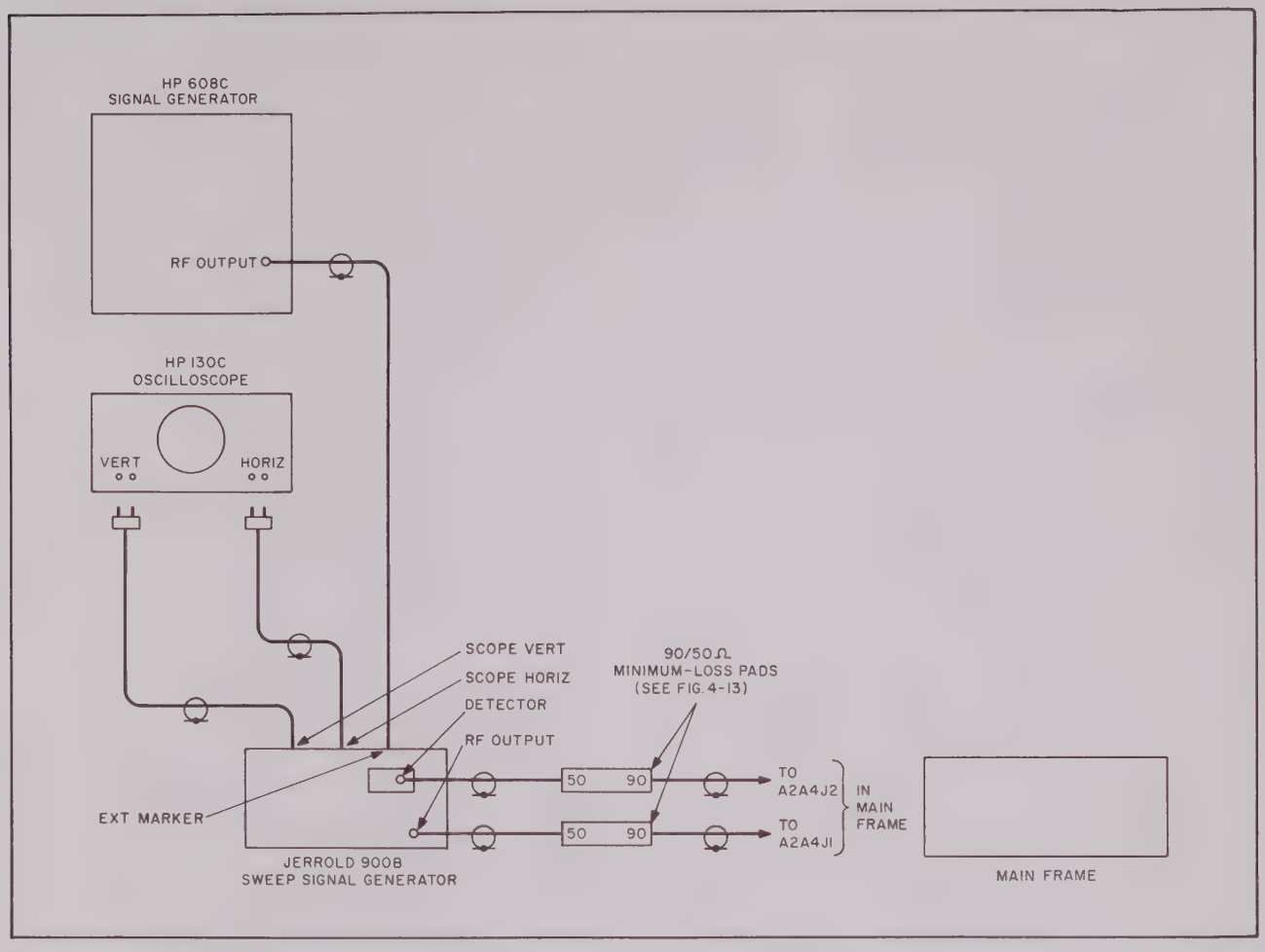


Figure 4-15. High Pass Filter A2A4 Alignment, Equipment Setup

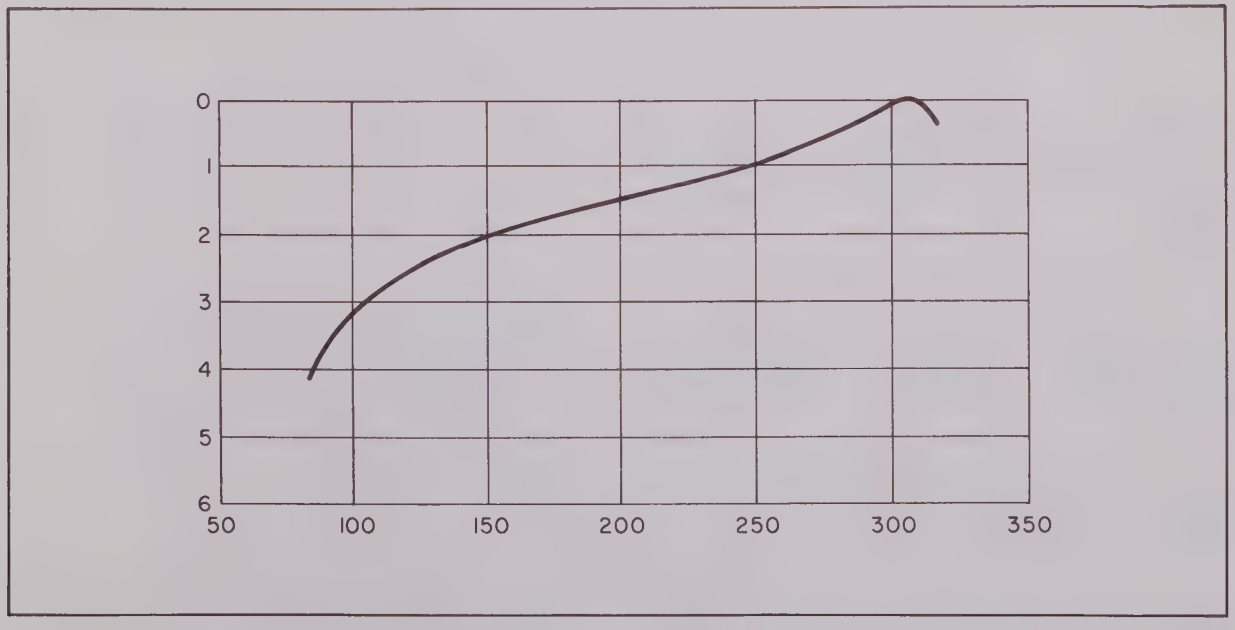


Figure 4-16. High Pass Filter A2A4 Frequency Response

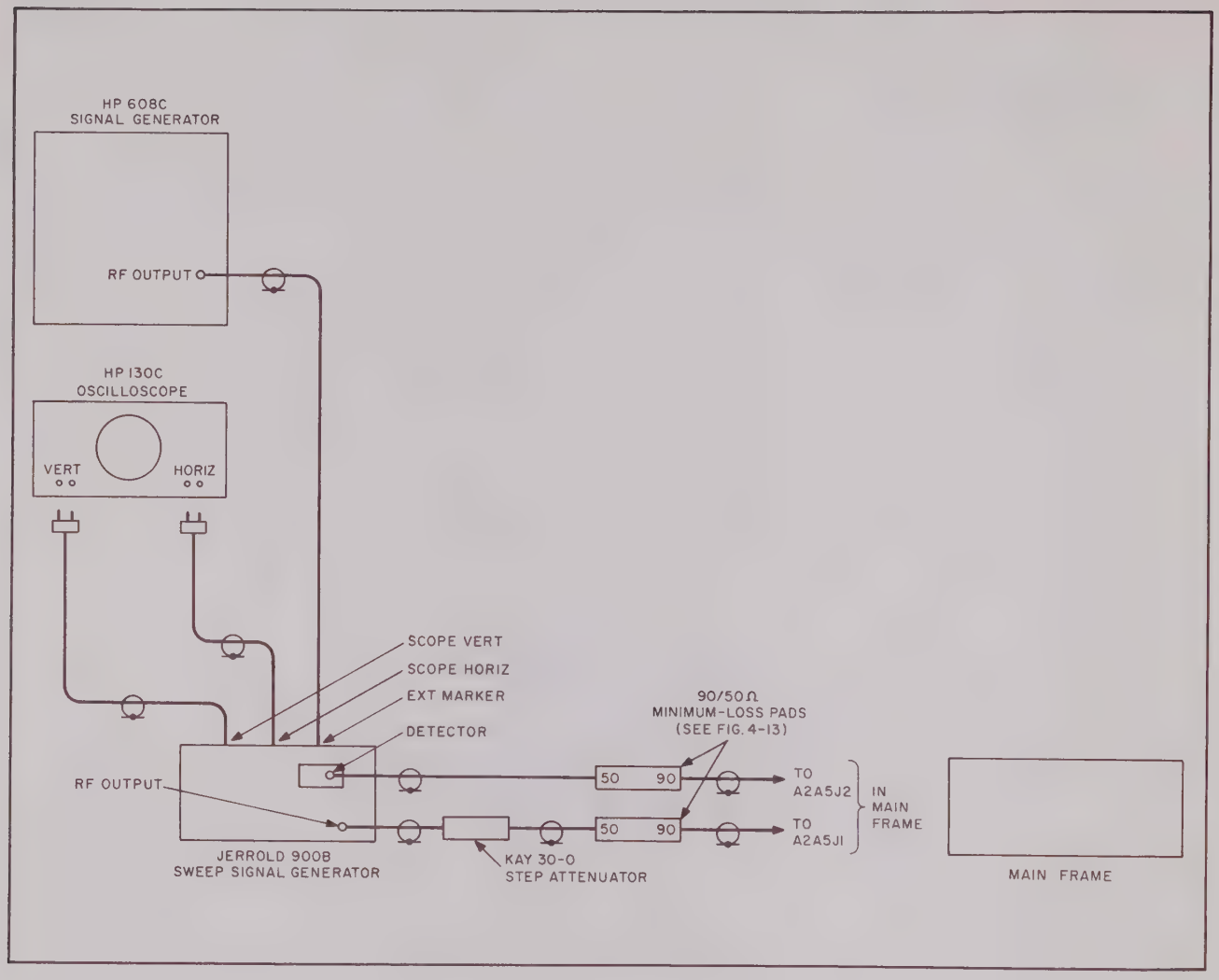


Figure 4-17. Low Pass Filter A2A5 Alignment, Equipment Setup

b. Tune the sweep generator to a center frequency of 160 MHz, a sweepwidth of 200 MHz and an output level of 0 dBm. Tune the signal generator to obtain a marker at 210 MHz. Set the attenuator for 0 dB insertion.

c. Adjust A2A5C2, A2A5C3 and A2A5C5 to obtain a response similar to that illustrated in figure 4-18.

d. Adjust the vertical gain of the oscilloscope to obtain a display of convenient amplitude. Trace the display on the oscilloscope screen with a marker pencil.

e. Disconnect the low pass filter and couple the two minimum-loss pads together by means of a short length of 90-ohm coaxial cable.

f. Insert step attenuation until the amplitude of the trace coincides with the pass band recorded in step d. The attenuation inserted should be 1 dB or less.

4-24. LOW PASS FILTER A2A6. To align this filter, proceed as directed in the following steps.

a. Connect the equipment as illustrated in figure 4-19.

b. Tune the sweep generator to a center frequency of 160 MHz, a sweepwidth of 200 MHz and an output level of 0 dBm. Tune the signal generator to obtain a marker at 210 MHz. Set the attenuator for 0 dB insertion.

c. Adjust A2A6C2, A2A6C3 and A2A6C5 to obtain a response similar to that illustrated in figure 4-18.

d. Adjust the vertical gain of the oscilloscope to obtain a display of convenient amplitude. Trace the display on the oscilloscope screen with a marker pencil.

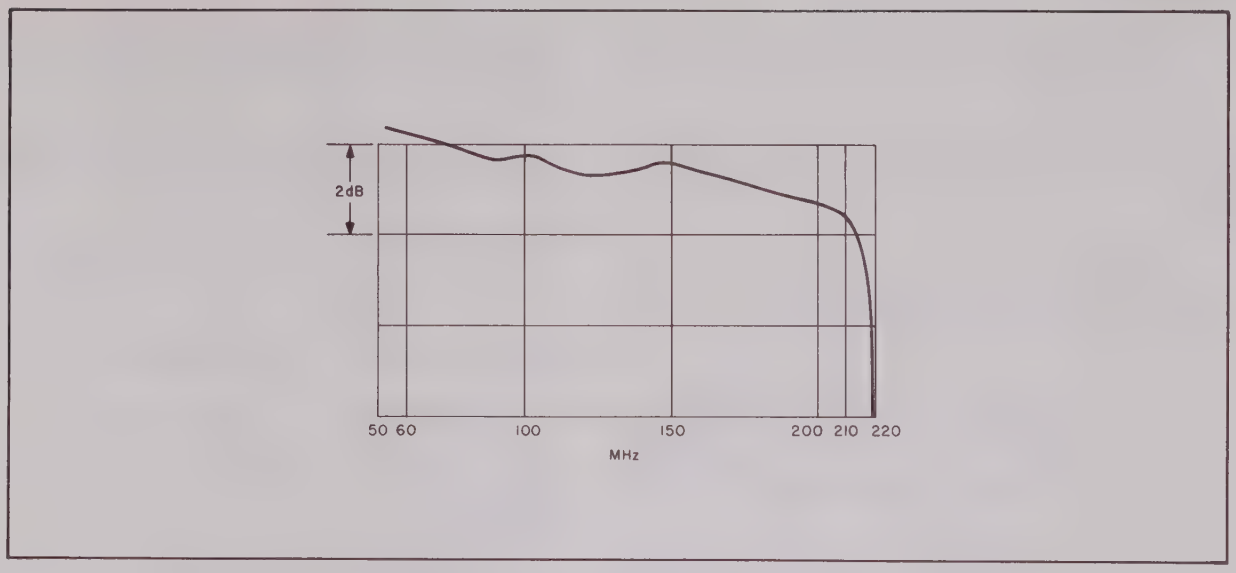


Figure 4-18. Low Pass Filters A2A5 and A2A6, Frequency Response

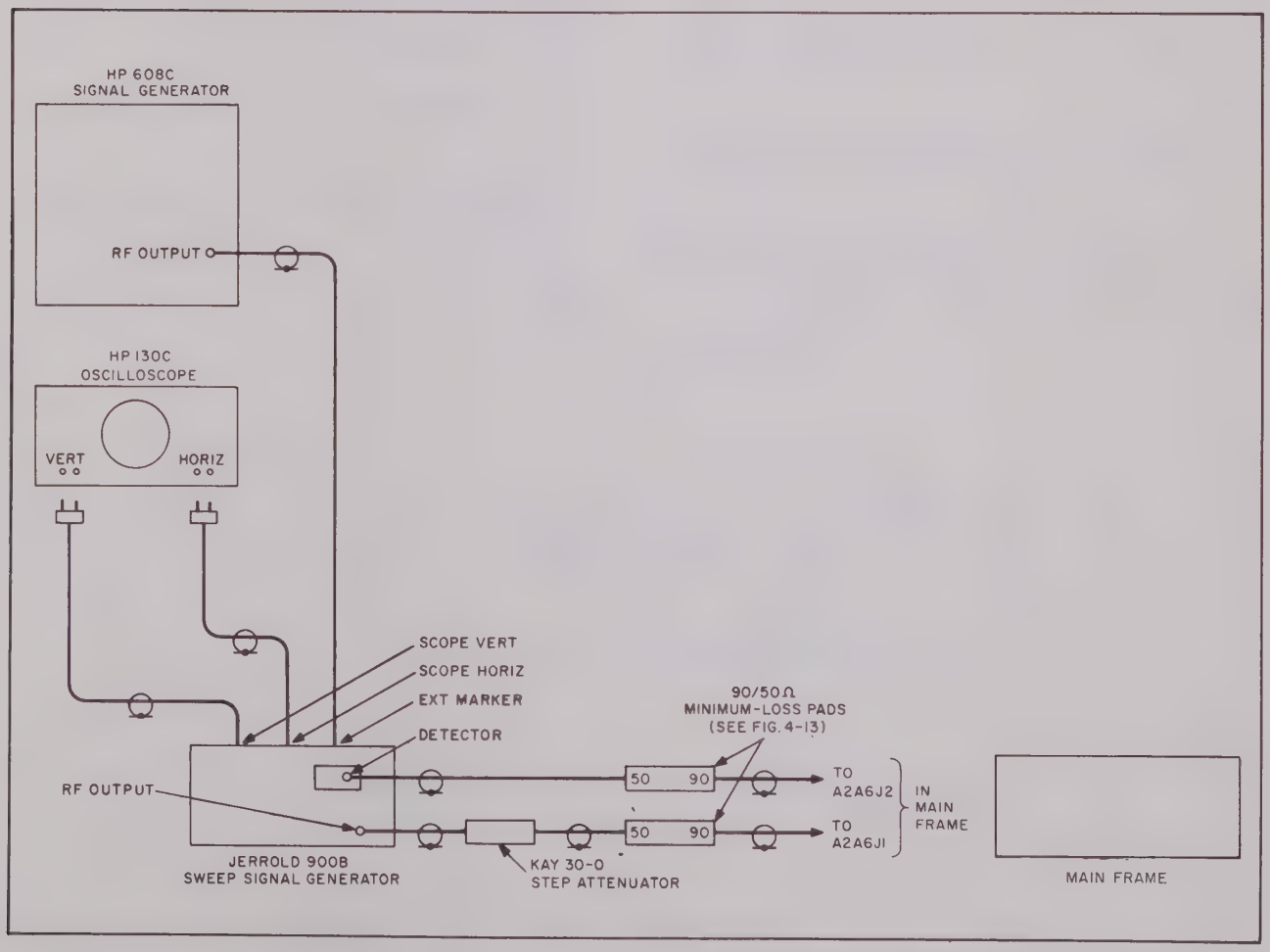


Figure 4-19. Low Pass Filter A2A6 Alignment, Equipment Setup

e. Disconnect the low pass filter and couple the two minimum-loss pads together by means of a short length of 90-ohm coaxial cable.

f. Insert step attenuation until the amplitude of the trace coincides with the pass band recorded in step d. The attenuation inserted should be 5 dB or less.

4-25. SWEPT OSCILLATOR A2A7. To align the swept oscillator, set the front panel controls as directed in paragraph 4-19 and then continue as indicated below.

a. Set the FREQ DISPERSION switch to 10 MHz/DIV and rotate the MARKER LEVEL control fully clockwise.

b. Set A9R17 and A9R18 fully clockwise.

c. Set A2A7R14 to mid-range.

d. Tune A2A7T3 to obtain a pip of maximum amplitude.

e. Rotate A2A7R9 fully clockwise and connect the equipment as illustrated in figure 4-20.

f. Set the comb generator for 10-MHz markers and adjust its output level to obtain a convenient display amplitude.

g. Adjust A2A7C8 to position the internal 160-MHz marker as far to the right side of the screen as possible (minimum capacitance).

h. Set the comb generator for both 10- and 1-MHz markers and rotate A2A7C8 counterclockwise so that the center frequency marker is 52 MHz from the graticule extreme right hand vertical line.

i. Adjust A2A7R9 for optimum linearity and reset A2A7C8 so that the center frequency marker is 52 MHz from the graticule extreme right hand vertical line.

j. Adjust A9R20 to position the internal 160-MHz marker pip coincident with the graticule f_o vertical line.

k. Adjust A9R17 to obtain a display dispersion of 100 MHz.

l. Set the FREQ DISPERSION switch to .3 MHz/DIV and adjust A9R21 to center the display on the screen.

m. Adjust A2A7R25 for optimum linearity.

n. Select that portion of the display which appears most linear and center it on the screen by adjusting A9R21.

o. Spread or compress the turns of A2A7L5 to position the internal 160-MHz marker at the graticule f_o vertical line.

p. Set the FREQ DISPERSION switch to .1 MHz/DIV and adjust the SIGNAL FREQ POSITION f_o COARSE and/or FINE control so that two pips appear on the screen, each pip equidistant from the graticule f_o vertical line.

q. Adjust A9R18 so that the pips coincide with the extreme left and right graticule vertical lines.

r. Adjust the SIGNAL FREQ POSITION f_o COARSE and/or FINE control to position the internal 160-MHz marker pip at the graticule f_o vertical line.

s. Disconnect the equipment from the setup of figure 4-20.

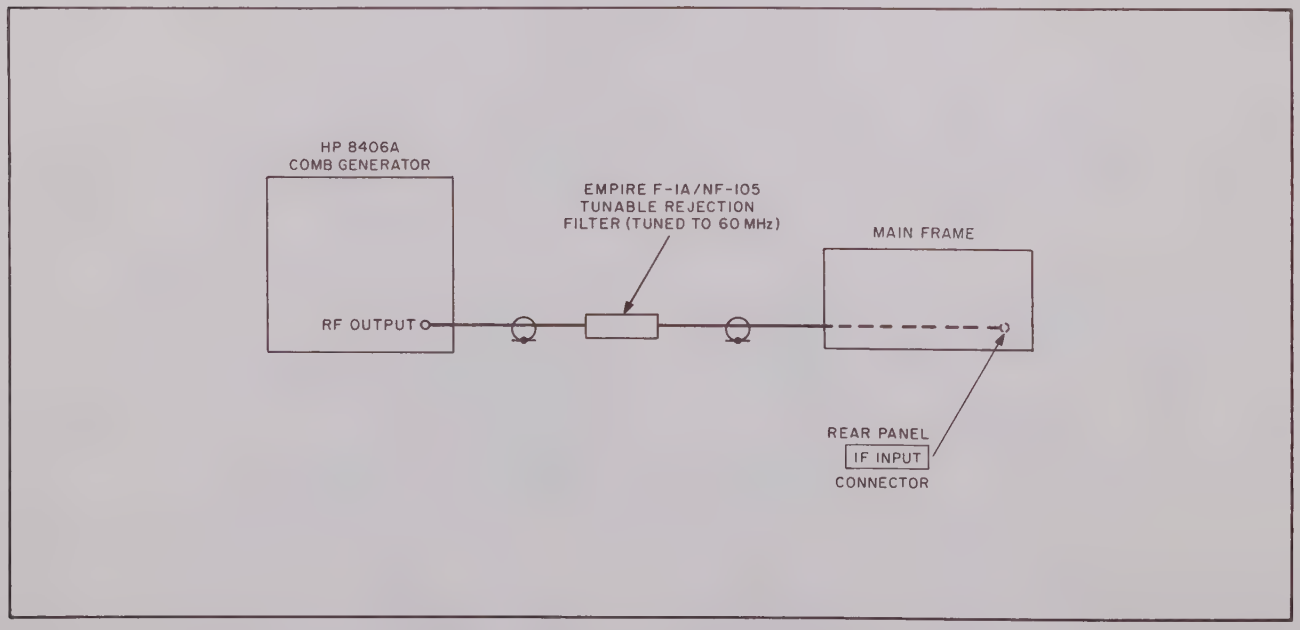


Figure 4-20. Swept Oscillator A2A7 Alignment, Equipment Setup

t. Couple an HP 608C Signal Generator, tuned to 160 MHz and adjusted for minimum output level, to the rear-panel IF INPUT connector.

u. Set the FREQ DISPERSION switch to .3 MHz/DIV and rotate the MARKER LEVEL control fully counterclockwise to OFF.

v. Increase the signal generator output level to -45 dBm and adjust the IF GAIN control to position the pip peak coincident with the LOG scale 0 DB line.

w. Tune the signal generator to 140 MHz and set its output level at -45 dBm.

x. Alternately adjust A2A7C11, A2A7T2 and A2A7R14 to minimize the pip amplitude; the pip peak should be reduced to below the LOG scale 40 DB line.

y. Set the FREQ DISPERSION switch to 10 MHz/DIV, set the signal generator for minimum output level, set the AMPLITUDE SCALE switch to LIN and rotate the IF GAIN control fully counterclockwise. Adjust the V POS screwdriver control to position the trace at the lowest graticule horizontal line.

z. Increase the signal generator output level and determine the display flatness; it should be within 2 dB.

aa. Set the FREQ DISPERSION switch to .1 MHz/DIV and rotate the BANDWIDTH VARIABLE control fully counterclockwise.

ab. Tune the signal generator to 160 MHz and adjust for minimum output level.

ac. Rotate the IF GAIN control clockwise to position the trace coincident with the LIN scale 0.2 line.

ad. Increase the signal generator output level until the signal pip peak is coincident with the LIN scale 0.4 line. Note the signal generator output level; it should be equal to or less than -110 dBm.

4-26. 60-MHz I-F AMPLIFIER A2A8. To align the 60-MHz i-f amplifier, proceed as directed in the following steps.

a. Connect the equipment as illustrated in figure 4-21.

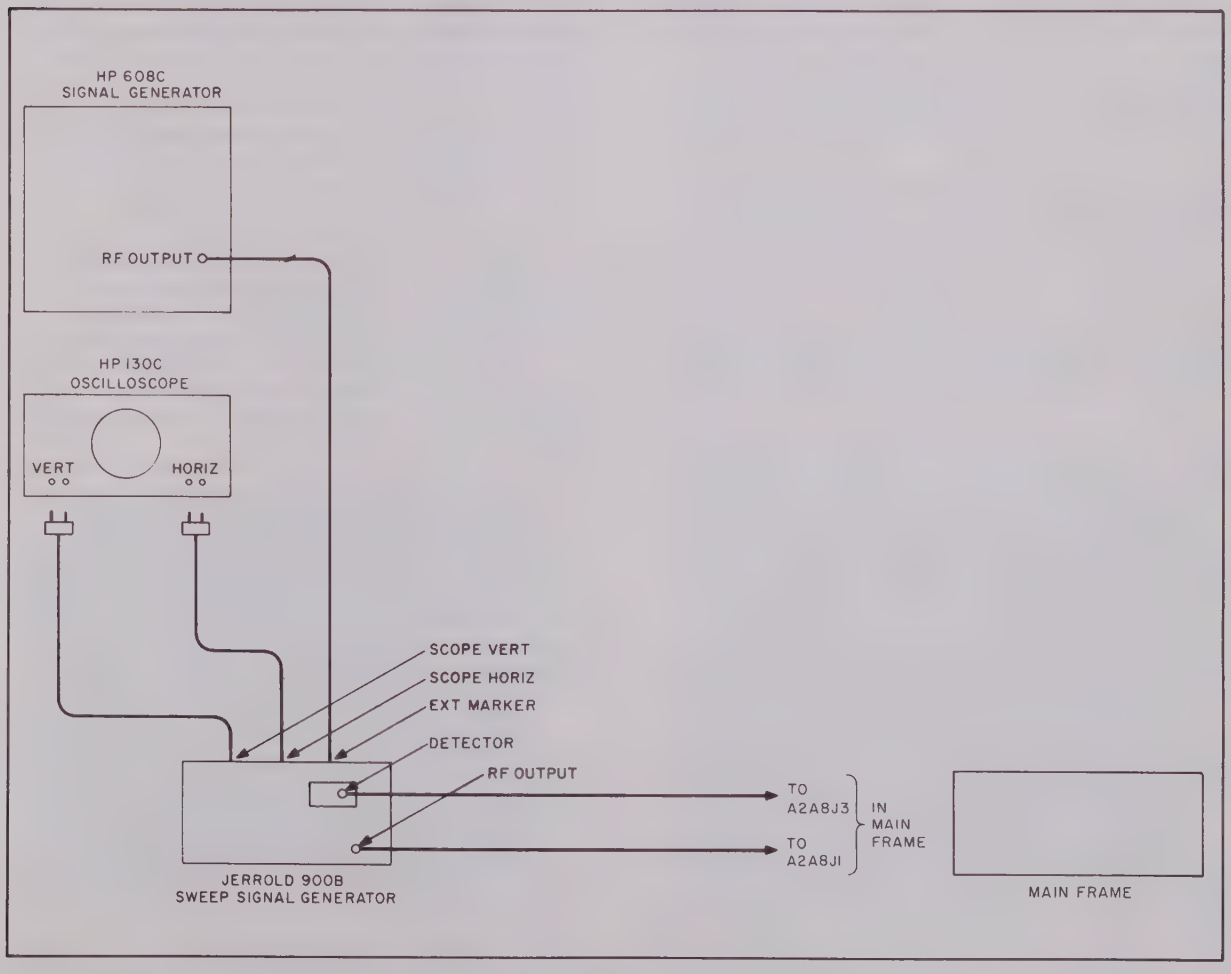


Figure 4-21. 60-MHz I-F Amplifier A2A8 Alignment, Equipment Setup

b. Tune the sweep generator to a center frequency of 60 MHz, a sweepwidth of 20 MHz and an output level of -10 dBm. Tune the signal generator for a 60-MHz marker output.

c. Adjust A2A8L4 and A2A8L1 to obtain an optimum response at 60 MHz. The frequency response should be symmetrical about 60 MHz and have a 3-dB bandwidth of between 8 and 10 MHz.

d. Disconnect A2P10 from A2A8J3 and disconnect A2W9P1 from A2A8J2. Connect A2P10 to A2A8J2.

e. Rotate the IF GAIN control fully counterclockwise.

f. Adjust A2A8L6, A2A8L8 and, if necessary, A2A8L4, to obtain an optimum response at 60 MHz. The frequency response should be symmetrical about 60 MHz and have a 3-dB bandwidth of between 3 and 5 MHz.

g. Connect A2P10 to A2A8J3 and connect A2W9P1 to A2A8J2.

4-27. 60/6.5-MHz CONVERTER A2A9. To align this converter, set the front panel controls as listed in paragraph 4-19 and then continue as directed below.

a. Rotate the MARKER LEVEL control fully clockwise.

b. Adjust A2A9L1 until the marker pip is displayed on the screen.

c. Adjust A2A9T2 and A2A9T3 to obtain a pip display of maximum amplitude.

d. Adjust A2A9T1 for minimum pip height and then rotate tuning slug counterclockwise to obtain a pip display of maximum height.

e. Rotate the slug of A2A9L1 counterclockwise until pip disappears. Rotate the slug clockwise until the pip reappears and then rotate an additional 1/2-turn clockwise.

4-28. ALIGNMENT PROCEDURES, BACK I-F ASSEMBLY A3.

4-29. The procedures for aligning the various printed circuit boards within back i-f assembly A3 are detailed in paragraphs 4-30 through 4-34.

4-30. 6.5-MHz WIDEBAND FILTER A3A1. To align this filter, set the front panel controls as listed in paragraph 4-19 and then continue as directed below.

a. Tune an HP 608C Signal Generator to 160 MHz and adjust for a minimum cw output level. Couple the signal generator to the rear-panel IF INPUT connector. Set the FREQ DISPERSION switch to 1 MHz/DIV.

b. Increase the signal generator output level to obtain a pip peak coincident with the LOG scale 10 DB line and adjust the SIGNAL FREQ POSITION f_o COARSE and/or FINE control to position the pip at the graticule f_o vertical line.

c. Set the BANDWIDTH switch to 1000 kHz and adjust A3A1C9 to obtain a pip display of maximum amplitude at the center of the screen.

d. Adjust A3A1R11 to position the pip peak coincident with the LOG scale 20 DB line.

e. Set the IF ATTENUATOR switches to 20 DB and set the AMPLITUDE SCALE switch to LIN. Readjust A3A1C9 to peak the response at the center of the screen and adjust the IF GAIN control to position the pip peak coincident with the LIN scale 1.0 line.

f. Determine the width of the pip at the LIN scale 0.7 point; it should be between 0.9 and 1.1 divisions.

4-31. 6.5-MHz NARROWBAND FILTER A3A2. To align this filter, set the front-panel controls as listed in paragraph 4-19 and then continue as directed in the following steps.

a. Tune an HP 608C Signal Generator to 160 MHz and adjust for minimum cw output level. Couple the signal generator to the rear-panel IF INPUT connector through a Kay 30-0 Step Attenuator. Set the attenuator for 0-dB insertion.

b. Set the BANDWIDTH switch to 10 kHz and set the FREQ DISPERSION switch to 100 kHz/DIV.

c. Increase the signal generator output level to obtain a display of convenient amplitude.

d. Adjust the SIGNAL FREQ POSITION f_o COARSE and/or FINE control to position the pip at the graticule f_o vertical line.

e. Disconnect A3W4P1 from A3A2J2 and disconnect A3W5P2 from A3A4J1. Connect length of 50-ohm coaxial cable between A3A2J2 and A3A4J1.

f. Increase the signal generator to obtain a pip peak coincident with the LOG scale 10 DB line.

g. Adjust A3A2C3, A3A2C5, A3A2C7, A3A2C9, A3A2C11, A3A2C13, A3A2C15 and A3A2C17 to obtain a maximum pip amplitude at the graticule f_o vertical line. Retune the above capacitors several times to obtain a smooth symmetrical response about the f_o line.

h. Set the external attenuator for 40-dB insertion, set the AMPLITUDE SCALE switch to LIN and adjust the signal generator output level to obtain a pip peak coincident with the LIN scale 1.0 line.

i. Determine the width of the display at the LIN scale 0.7 point; it should be between 1.5 and 2 divisions wide. The pip should also be smooth and symmetrical about the graticule f_o vertical line. Note that it may be necessary to repeat steps a through i several times until the proper response is obtained.

j. After the proper response has been obtained, connect A3W4P1 to A3A2J2 and connect A3W5P2 to A3A4J1.

4-32. 6.5-MHz VARIABLE BANDWIDTH AMPLIFIER A3A3. To align the variable bandwidth amplifier, set the front panel controls as listed in paragraph 4-19 and then continue as directed in the following steps.

a. Rotate screwdriver controls A9R6 (A 50 kHz Adj), A9R4 (A 1.5 kHz Adj), A9R10 (B 50 kHz Adj), and A9R8 (B 1.5 kHz Adj) fully clockwise.

b. Tune an HP 608C Signal Generator to 160 MHz and adjust for a cw output level of -45 dBm.

c. Set the BANDWIDTH switch to VAR and set the FREQ DISPERSION switch to 100 kHz/DIV.

d. Adjust the SIGNAL FREQ POSITION f_o COARSE and/or FINE control to position the response at the graticule f_o vertical line.

e. Bypass 6.5-MHz narrowband filter A3A2. Note various responses to the right of the main response centered on the screen.

f. Remove A3A3Y2 from its socket and note the fundamental response of the crystal at the center of the screen.

g. Rotate the BANDWIDTH VARIABLE control counterclockwise until a significant reduction of the broadband response is obtained.

h. Adjust A3A3C13 to minimize the response on the left side of the screen.

i. Rotate the BANDWIDTH VARIABLE control fully clockwise and adjust A3A3L5 to minimize the fundamental response at the center of the screen (until the top of the display is flat).

j. Adjust A3A3C11 to obtain maximum rejection on the right side of the fundamental response (see figure 4-22a).

k. Rotate the BANDWIDTH VARIABLE control counterclockwise until the width of the fundamental response is two (2) divisions wide when measured 25 dB below its peak (see figure 4-22b).

l. Adjust A3A3C13 to obtain symmetry about the fundamental response (down to 25 dB below the peak).

m. Rotate the BANDWIDTH VARIABLE control fully clockwise and adjust A3A3L5 to obtain a flat response (see figure 4-22a).

n. Trim A3A3C11 for maximum skirt rejection.

o. Repeat steps k and l.

p. Set the FREQ DISPERSION switch to 30 kHz/DIV and set the AMPLITUDE SCALE switch to LIN.

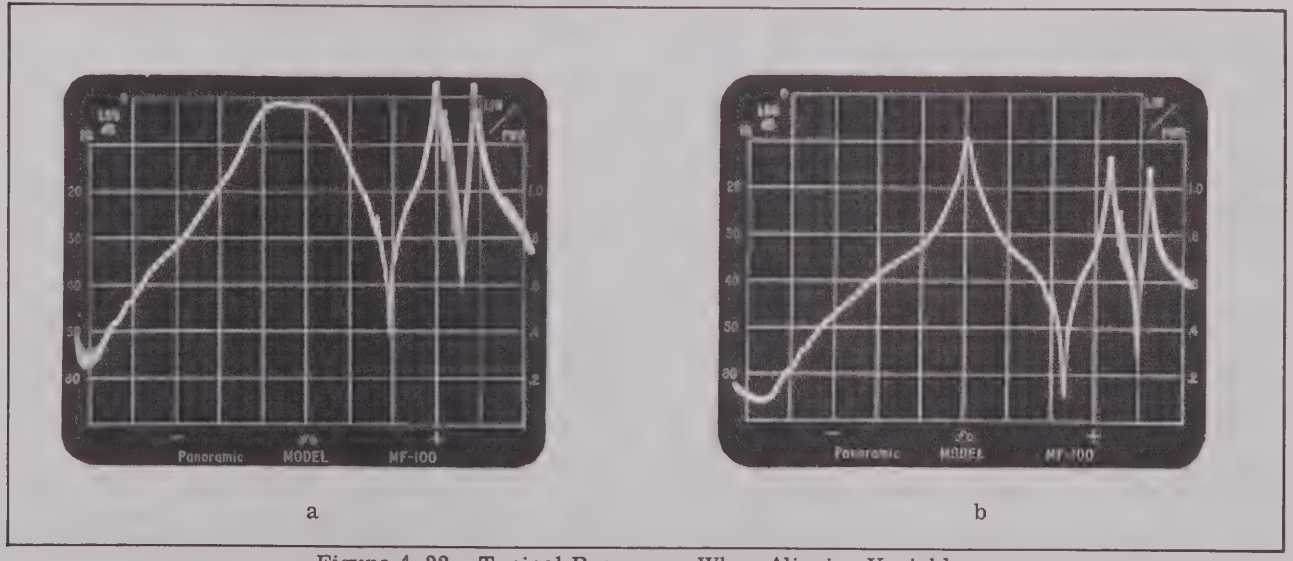
q. Adjust the signal generator output level to obtain a pip peak coincident with the LIN scale 1.0 line.

r. Adjust A3A3L5 to obtain a flat response.

s. Set the BANDWIDTH switch to 30 kHz, set the FREQ DISPERSION switch to 10 kHz/DIV and adjust screwdriver control A9R6 (A 50 kHz Adj) to obtain a pip 3-dB bandwidth of 50 kHz (5 divisions).

t. Set the BANDWIDTH switch to 1 kHz, set the FREQ DISPERSION switch to 1 kHz/DIV and adjust screwdriver control A9R4 (A 1.5 kHz Adj) to obtain a pip 3-dB bandwidth of 1.5 kHz (1.5 divisions).

u. Due to interaction between controls, it may be necessary to repeat steps s and t several times until no further adjustment of either control is required to obtain the specified indications.



a b

Figure 4-22. Typical Responses When Aligning Variable Bandwidth Amplifier A3A3

v. Insert A3A3Y2 into its socket and remove A3A3Y1.

w. Set the AMPLITUDE SCALE switch to LOG repeat steps b, c and g.

x. Adjust A3A3C26 to minimize the response on the left side of the screen.

z. Rotate the BANDWIDTH VARIABLE control fully clockwise and adjust A3A3L12 to minimize the fundamental response at the center of the screen (until the top of the display is flat).

aa. Adjust A3A3C27 to obtain maximum rejection on the right side of the fundamental response (see figure 4-22a).

ab. Rotate the BANDWIDTH VARIABLE control counterclockwise until the width of the fundamental response is two (2) divisions wide when measured 30 dB below its peak (see figure 4-22b).

ac. Adjust A3A3C26 to obtain symmetry about the fundamental response (down to 30 dB below the peak).

ad. Rotate the BANDWIDTH VARIABLE control fully clockwise and adjust A3A3L12 to obtain a flat response (see figure 4-22b).

ae. Trim A3A3C27 for maximum skirt rejection.

af. Repeat steps ab and ac.

ag. Set the FREQ DISPERSION switch to 30 kHz/DIV and set the AMPLITUDE SCALE switch to LIN.

ah. Adjust the signal generator output level to obtain a pip peak coincident with the LIN scale 1.0 line.

ai. Adjust A3A3L12 to obtain a flat response.

aj. Set the BANDWIDTH switch to 30 kHz, set the FREQ DISPERSION switch to 10 kHz/DIV and adjust screwdriver control A9R10 (B 50 kHz Adj) to obtain a pip 3-dB bandwidth of 50 kHz (5 divisions).

ak. Set the BANDWIDTH switch to 1 kHz, set the FREQ DISPERSION switch to 1 kHz/DIV and adjust screwdriver control A9R8 (B 1.5 kHz Adj) to obtain a pip 3-dB bandwidth of 1.5 kHz (1.5 divisions).

al. Due to interaction between controls, it may be necessary to repeat steps aj and ak several times until no further adjustment of either control is required to obtain the specified indications.

am. Replace A3A3Y1 into its socket.

an. Adjust A3A3C5 and A3A3C23 to obtain a maximum amplitude response for the main pip.

ao. Replace 6.5-MHz narrowband filter A3A2 into the signal path.

ap. Adjust A3A3C29 to obtain a flat-topped response.

aq. Set the BANDWIDTH switch to 1000 kHz, set the FREQ DISPERSION switch to 1 MHz/DIV and set the AMPLITUDE SCALE switch to LOG. Adjust the signal generator output level to obtain a pip peak coincident with the LOG scale 20 DB line.

ar. Set the BANDWIDTH switch to 100 kHz and adjust A3A3R25 so that the pip peak is coincident with the LOG scale 10 DB line.

4-33. LOG AMPLIFIER A3A4. To align the log amplifier, set the front panel controls as listed in paragraph 4-19 and then continue as directed below.

a. Tune an HP 608C Signal Generator to 160 MHz and adjust for a cw output level of -45 dBm. Connect the signal generator to the rear-panel IF INPUT connector through a Kay 30-0 (432C) Step Attenuator. Set the external attenuator for 0 dB insertion.

b. Set the BANDWIDTH switch to 10 kHz, set the FREQ DISPERSION switch to 0.1 MHz/DIV and adjust the SIGNAL FREQ POSITION f_0 COARSE and/or FINE control to position the signal at the graticule f_0 vertical line.

c. Adjust the V POS screwdriver control to position the trace baseline coincident with the lowest graticule horizontal line.

d. Set the IF ATTENUATOR switches to 40 DB and set the AMPLITUDE SCALE switch to LIN.

e. Adjust A3A4C6, A3A4C12, A3A4C16 and A3A4C26 to maximize the pip amplitude.

f. Adjust the IF GAIN control to position the pip peak coincident with the LIN scale 1.0 line.

g. Set the AMPLITUDE SCALE switch to LOG and adjust A3A4C36 and A3A4C44 for maximum pip amplitude.

h. Set the IF ATTENUATOR switches to 60 DB and adjust A3A4R44 to position the pip peak coincident with the LOG scale 60 DB line.

i. Set the IF ATTENUATOR switches to 00 DB and adjust A3A4R48 to position the pip peak coincident with the LOG scale 0 DB line.

j. Set the external attenuator for 10 dB insertion and note the position of the pip peak; it should be within ±0.2 divisions of the LOG scale 10 DB line. If it is not, continue as directed in the following additional steps.

1. Adjust the IF GAIN control to obtain a pip peak coincident with the LOG scale 10 DB line.

2. Insert 50-dB of external attenuation and adjust A3A4R44 to obtain a pip peak coincident with the LOG scale 60 DB line.

3. Remove 60-dB of external attenuation and adjust A3A4R48 to obtain a pip peak coincident with the LOG scale 0 DB line.

k. Repeat step j.

l. Insert 50-dB of external attenuation (in 10-dB increments) and, after each step, note the position of the pip peak; it should be within ±0.2 divisions of the appropriate LOG scale line.

4-34. LIN/POWER AMPLIFIER A3A5. To align the lin/power amplifier, set the front panel controls as listed in paragraph 4-19 and then continue as directed below.

a. Tune an HP 608C Signal Generator to 160 MHz and adjust for minimum output level. Couple the signal generator, through a Kay 30-0 Step Attenuator, to the rear-panel IF INPUT connector. Set the step attenuator for 0-dB insertion.

b. Increase the signal generator output level to obtain a pip peak coincident with the LOG scale 0 DB line.

c. Insert 40-dB of external attenuation and set the AMPLITUDE SCALE switch to LIN.

d. Rotate A3A5R8 fully counterclockwise and then adjust A3A5R11 so that the baseline coincides with the lowest horizontal graticule line.

e. Adjust A3A5C2 to obtain maximum pip amplitude and then adjust A3A5R8 to position the pip peak coincident with the LIN scale 1.0 line.

f. Set the AMPLITUDE SCALE switch to PWR.

g. Set A3A5R18 to mid-range and rotate A3A5R17 fully clockwise.

h. Adjust A3A5R21 so that the baseline coincides with the lowest horizontal graticule line.

i. Carefully rotate A3A5R17 counterclockwise until the baseline just starts to rise upscale.

j. Adjust A3A5R18 to position the pip peak coincident with the PWR scale 1.0 line.

k. Adjust A3A5R21 to position the baseline coincident with the lowest graticule horizontal line.

l. Insert 3-dB of external attenuation (a total of 43 dB) and note the position of the pip peak; it should be at the PWR scale 0.5 point. If the pip does not coincide with the PWR scale 0.5 point, adjust A3A5R17 to obtain this indication, remove 3-dB of external attenuation and repeat steps j, k and l.

4-35. ALIGNMENT PROCEDURES, SWEEP AND DEFLECTION CIRCUITRY.

4-36. To align the sweep and deflection circuitry, proceed as directed in the following steps.

a. Set the front panel controls as listed below.

Control	Setting
SCALE ILLUMINATION control	Fully cw
IF ATTENUATOR switches	00 DB
BRIGHTNESS control	Fully cw
FOCUS control	Mid-range
INTENSIFIER control	Fully ccw
FREQ DISPERSION switch	.3 MHz/DIV
FREQ DISPERSION VARIABLE control	CAL (fully cw)
MARKER MODULATION switch	OFF
MARKER LEVEL control	OFF (fully ccw)
BANDWIDTH switch	1 kHz
BANDWIDTH VARIABLE control	Fully cw
SWEEP switch	3 MS/DIV
SWEEP VARIABLE control	CAL (fully cw)
SWEEP/SYNC switch	LINE CAL
H POS screwdriver control	Mid-range
H SIZE screwdriver control	Fully ccw
V POS screwdriver control	Mid-range
AMPLITUDE SCALE switch	LOG
IF GAIN control	Fully ccw
MANUAL control	Any

b. Adjust the FOCUS control to obtain a sharply focused display.

c. Rotate the BRIGHTNESS control fully counterclockwise and then clockwise 90°. Adjust A9R27 until the display just vanishes. Adjust the BRIGHTNESS control to obtain a display of convenient intensity.

d. Adjust the H POS screwdriver control to center the display on the screen. Adjust the H SIZE screwdriver control to extend the sweep 1/4-division beyond the extreme lef-hand graticule vertical line. Adjust A5R80 to extend the sweep 1/4-division beyond the extreme right-hand graticule vertical line.

e. Rotate A4R30 fully clockwise.

f. Adjust A9R24 to obtain a display of two full periods.

g. Adjust the V POS screwdriver control so that the base of the displayed waveform coincides with the LOG scale 60 DB line.

h. Set the SWEEP/SYNC switch to LINE USE and adjust A4R1 so that the base of the displayed trace coincides with the LOG scale 60 DB line.

i. Set the SWEEP/SYNC switch to LINE CAL and adjust A4R30 so that the displayed waveform is five divisions high.

j. Adjust the V POS screwdriver control so that the bottom of the displayed waveform is 1/2-division below the lowest horizontal graticule line.

k. Set the SWEEP/SYNC switch to LINE USE and adjust A4R1 to position the base of the displayed trace coincident with the lowest horizontal graticule line.

l. Set the SWEEP/SYNC switch to LINE CAL; the uppermost portion of the displayed waveform should be coincident with the LOG scale 20 DB line.

m. Connect the equipment as illustrated in figure 4-23. Adjust the time mark generator for pulses every 5 milliseconds.

n. Set the SWEEP/SYNC switch to INT SYNC and rotate A5R95 fully clockwise.

o. Rotate the BANDWIDTH VARIABLE control counterclockwise until the time mark pulses are two divisions high.

p. Rotate A5R95 counterclockwise until the sweep just ceases.

q. Rotate the BANDWIDTH VARIABLE control fully clockwise, set the SWEEP switch to 1000 uS/DIV and set the time mark generator for pulses every 1 millisecond.

r. Adjust A9R24 so that the displayed pulses are separated by one division.

4-37. REMOVAL AND REPLACEMENT PROCEDURES.

4-38. CRT REMOVAL. To remove the CRT from the Main Frame, proceed as directed in the following steps.

WARNING

The normal operating voltages of the CRT are dangerous to life. Be sure to short all high-voltage points to ground before reaching into exposed areas around the CRT.

a. Remove the four screws that secure the bezel to the front panel and remove the bezel, graticule and the fitted gasket.

b. Remove the multipin socket at the base of the CRT and disconnect the anode connector.

c. Loosen the two screws on the clamp near the rear of the CRT.

d. Carefully withdraw the CRT. Install a replacement CRT, using the reverse of the sequence given above, but do not install the bezel and graticule and do not tighten the clamp screws.

Note

The gasket fits tightly around the CRT and is fully installed when the face of the gasket is flush with the front panel.

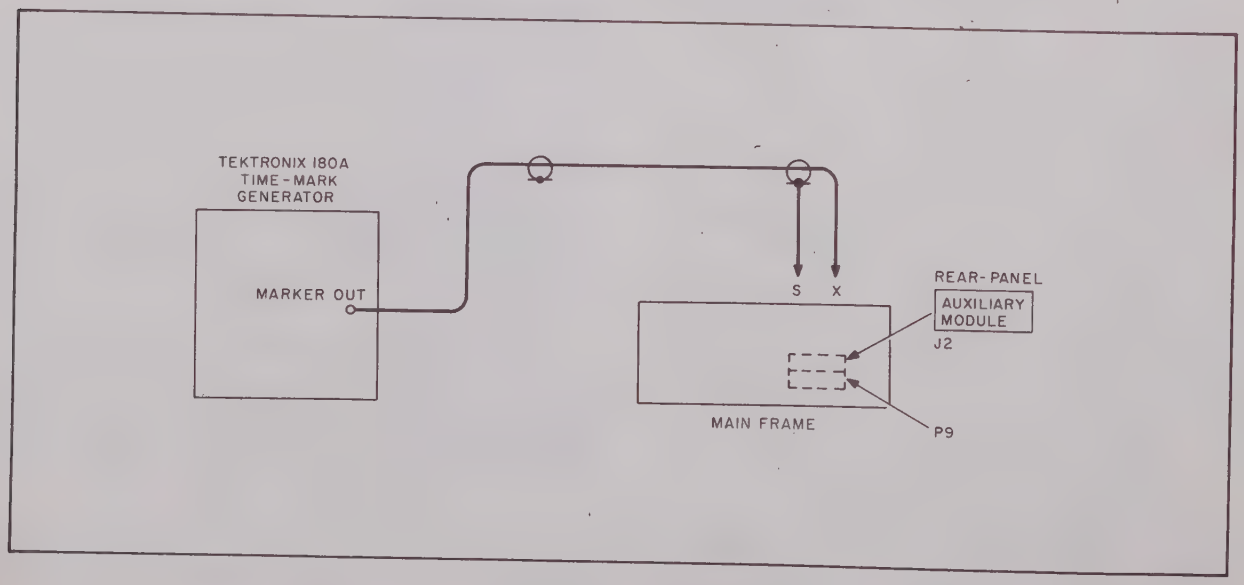


Figure 4-23. Sweep Circuitry Alignment, Equipment Setup

e. Energize the Main Frame and obtain a sharply defined trace. If the trace is tilted with respect to the horizontal, place a strip of masking tape parallel to the trace and de-energize the equipment.

f. See the warning preceding step a. Manually rotate the CRT until the masking tape is parallel to the horizontal.

g. Tighten the two clamp screws, remove the masking tape and install the graticule and bezel.

4-39. HIGH VOLTAGE POWER SUPPLY A6, REMOVAL. To remove the high-voltage power supply, proceed as directed in the following steps.

WARNING

The normal operating voltages of the CRT are dangerous to life. Be sure to short all high-voltage points to ground before reaching into exposed areas around the CRT.

a. Remove the two screws which secure the high-voltage power supply to the underside of the Main Frame.

b. Carefully grasp the side opposite the connector and, after lifting the side approximately one inch from the mounting bracket, pull the assembly from its multipin connector.

c. To gain access to the components within the assembly, remove the remaining screws and lift off the cover.

d. Before installing a replacement component, clear the area of epoxy coating. After the replacement component has been soldered in place, coat the exposed area with Polyurethane 1A27 (Humiseal Division of Columbia Technical Corp.)

4-40. I-F ATTENUATOR A1, REMOVAL. To remove the i-f attenuator assembly, proceed as follows.

a. Loosen the setscrews in each of the front panel IF ATTENUATOR knobs. Remove the knobs.

b. Disconnect the input and output cables from the assembly. It is not necessary to remove the jumper cable.

c. Remove the two screws that hold the rear plate to the frame.

d. Grasping the attenuator assembly with one hand, loosen and remove the two front panel screws (which were hidden behind the attenuator knobs) which secure the attenuator to the front panel. Carefully remove the attenuator from the Main Frame.

Note

The i-f attenuator assembly is not repairable in the field. The assembly should not be opened but should be returned to the factory for repairs.

4-41. VOLTAGE MEASUREMENTS

4-42. The voltage measurements for the active elements within the Main Frame are listed in table 4-7. Unless otherwise noted, all measurements were made with a vtvm with respect to chassis ground after the front panel controls were set per table 4-2.

TABLE 4-7. VOLTAGE MEASUREMENTS, MAIN FRAME CHASSIS

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3613	+12.5	+12.0	+12.0
Q2	2N3613	+18.0	+17.7	+12.8
Q3	2N3613	+6.9	+6.6	+0.4
Q4	2N3613	+0.2	-0.2	0
Q5	MJ2252	+100	+100	+138

TABLE 4-8. VOLTAGE MEASUREMENTS, MARKER OSCILLATOR A2A1

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1 [1,2]	2N3563	+0.9	0	+10.6
Q2 [1,2]	2N3563	-7.9	-7.3	-3.9
Q3 [1,3]	2N3563	-6.6	-6.0	0
Q4 [1,4]	2N3563	-7.7	-8.7	0

Notes: 1. MARKER LEVEL switch rotated clockwise from OFF position.
2. MARKER MODULATION switch set to OFF.
3. MARKER MODULATION switch set to 10 MHz.
4. MARKER MODULATION switch set to 1 MHz.

TABLE 4-9. VOLTAGE MEASUREMENTS, 160-MHz WIDEBAND AMPLIFIER A2A3

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	S24058	+2.2	+2.9	+8.6
Q2	S24058	+1.1	+1.8	+9.9
Q3	S24058	+1.1	+1.8	+10.2
Q4	S24058	+1.1	+1.8	+10.8

TABLE 4-10. VOLTAGE MEASUREMENTS, SWEPT LOCAL OSCILLATOR A2A7

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3642	-0.5	+0.5	+16.5
Q2	132-0317-001	+22.2	+21.5	+96.0
Q3	2N3563	+0.38	0	+11.2
Q4	2N3932	+4.65	+5.5	+11.8
Q5 [1]	2N3563	+0.85	0	+11.4
Q6 [1]	SE7010	+15.5	+15.5	+64.0
Q7 [1]	2N3565	-0.6	-0.03	+15.5

Notes: 1. FREQ DISPERSION switch set to .3 MHz/DIV

TABLE 4-11. VOLTAGE MEASUREMENTS, 60-MHz I-F AMPLIFIER A2A8

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3563	+5.1	+5.8	+11.6
Q2	2N3563	+5.1	+5.8	+11.6
Q3	SE5001	-1.15	-0.43	+4.0
Q4	2N3563	+5.3	+6.0	+11.7

TABLE 4-12. VOLTAGE MEASUREMENTS, 60-MHz TO 6.5-MHz CONVERTER A2A9

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3563	+4.6	+5.1	+10.2
Q2	2N3563	-6.2	-5.8	0

TABLE 4-13. VOLTAGE MEASUREMENTS, 6.5-MHz WIDEBAND FILTER A3A1

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3563	-5.6	-4.75	0

Note: BANDWIDTH switch set to 1000 kHz

TABLE 4-14. VOLTAGE MEASUREMENTS, 6.5-MHz NARROWBAND FILTER A3A2

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3694	-6.3	-5.7	0
Q2	2N3694	-6.2	-5.6	0

TABLE 4-15. VOLTAGE MEASUREMENTS, 6.5-MHz VARIABLE BANDWIDTH I-F AMPLIFIER A3A3

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3694	-0.74	-0.14	+11.0
Q2	2N3015	-0.6	0	+4.25

TABLE 4-15. VOLTAGE MEASUREMENTS, 6.5-MHz VARIABLE BANDWIDTH I-F AMPLIFIER A3A3 (Cont'd)

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q3	2N3015	-5.6	-5.0	+6.0
Q5	2N3694	-0.6	0	+5.4
Q5	2N3694	-5.8	-5.2	+5.3
Q6	2N3694	-0.6	0	+4.5
Q7	2N3694	-0.6	0	+11.5
Q8	2N3642	-1.2	-0.6	+11.4

TABLE 4-16. VOLTAGE MEASUREMENTS, LOG AMPLIFIER A3A4

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	SE3002	-7.3	-6.6	0
Q2	2N3646	-7.2	-6.6	0
Q3	2N3646	-7.2	-6.6	0
Q4	2N3694	-1.4	-0.84	+10.5
Q5	2N3646	-7.3	-6.7	0
Q6	2N3646	-7.5	-6.8	0
Q7	2N3646	-7.5	-7.0	0
Q8	2N3568	-0.5	+0.025	+11.9
Q9	2N3638	-11.3	-0.49	+0.18

TABLE 4-17. VOLTAGE MEASUREMENTS, LIN/POWER AMPLIFIER A3A5

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3641	-7.4	-6.9	+11.5
Q2	2N3568	-0.53	0	+11.6
Q3	2N3638	0	-0.53	-11.5
Q4	2N3638	+0.7	-0.06	-11.5
Q5	U148	+4.6 (S)	+9.6 (G)	-0.05 (D)
Q6	2N3568	-0.6	-0.05	+11.8
Q7	2N3638	0	-0.6	-11.5

TABLE 4-18. VOLTAGE MEASUREMENTS, DEFLECTION AMPLIFIERS A4

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3694	-0.55	0	+9.5
Q2	2N3694	-0.55	0	+8.8
Q3	2N3638	+9.5	+8.8	+0.126
Q4	2N3694	-0.57	0	+9.3
Q5	2N3694	-0.57	0	+8.8
Q6	2N3638	+9.5	+8.8	-0.075
Q7	2N3641	-5.1	-4.35	-4.4
Q8	2N3440	-0.3	+0.126	+126
Q9	2N3440	-4.0	-0.85	+200
Q10	2N3641	-7.0	-6.5	-2.75
Q11	2N3440	+0.58	+1.1	+150
Q12	2N3440	+0.075	+0.58	+200

TABLE 4-19. VOLTAGE MEASUREMENTS, SAWTOOTH/INTENSIFIER A5

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q2	2N3694	-0.6	0	+11.6
Q3	2N3641	-0.55	0	+6.7
Q4	2N3646	+3.0	+3.6	+3.2
Q5	2N3646	+3.0	+2.85	+10.6
Q6	2N3638	+10.6	+10.0	+4.9
Q7	2N3641	+4.35	+4.9	+11.6
Q8	2N3440	+5.4	+5.9	+235
Q9	2N3440	+235	+235	+297
Q10	2N3646	+5.8	+6.4	+11.7
Q11	2N3646	+5.9	+6.5	+6.4
Q12	2N3646	+6.0	+2.2	+11.0
Q13	2N3638	+5.9	+5.3	0
Q14	2N3638	+11.5	+11.6	-11.4

TABLE 4-19. VOLTAGE MEASUREMENTS, SAWTOOTH/INTENSIFIER A5 (Cont'd)

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q15	2N1480	-4.0	-11.4	+10.8
Q16	2N2945	+10.9	+10.5	+0.84
Q17	2N3638	-4.0	-4.6	-11.8
Q18	2N3641	-4.6	-4.0	0
Q19	2N3646	0	+0.76	+0.08
Q19[1]	2N3646	0	+0.74	+0.28
Q20	2N3646	0	-0.81	+11.5
Q20[1]	2N3646	0	-0.78	+11.6
Q21	2N3646	0	+0.74	+0.13
Q21[1]	2N3646	0	+0.82	+0.1
Q22	2N3646	0	+0.74	+0.06
Q22[1]	2N3646	0	-0.62	+8.8
Q23	2N3646	0	-0.72	+8.6
Q23[1]	2N3646	0	+0.72	+0.19
Q24	2N3646	0	+0.6	+0.77
Q25	2N3646	0	+0.68	+0.76
Q26	2N3646	0	+0.75	+0.1
Q27	2N3646	0	+0.73	+0.16
Q27[1]	2N3646	0	+0.72	+0.19
Q28	2N3646	0	+0.7	+0.14
Q28[1]	2N3646	0	+0.72	+0.14
Q29	2N3646	-0.8	+0.2	+12.0
Q30	2N5306	-0.26	-0.8	-12.0
Q31	2N3646	+0.69	+0.21	+9.3
Q32	2N3646	+0.69	+1.4	+0.78
Q33	2N3646	0	-0.98	+7.4
Q34	2N5306	-1.1	0	+12.0
Q35	2N5306	-1.1	0	+6.0
Q36	2N3646	+0.69	-0.2	+9.9

TABLE 4-19. VOLTAGE MEASUREMENTS, SAWTOOTH/INTENSIFIER A5 (Cont'd)

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q37	2N3646	+0.7	+1.4	+0.78
Q38	2N3646	0	-1.28	+8.2
Q39	2N3646	0	+0.56	+0.98
Q40	2N3638	+11.8	+11.6	+0.56

Notes: 1. FREQ DISPERSION switch set to 0, BANDWIDTH switch set to 1000 kHz, SWEEP switch set to 1000 uS/DIV, SWEEP/SYNC switch set to INT (red) and IF GAIN control adjusted to trigger the sweep at two divisions of noise.

TABLE 4-20. VOLTAGE MEASUREMENTS, POWER SUPPLY CONTROL A8

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3440	+100	+101	+124
Q2	2N3440	+101	+101	+102
Q3	2N3440	+75	+76	+100
Q4	2N3440	+75	+76	+102
Q5	2N3638	+16	+16	+12
Q6	2N3694	+5.0	+5.6	+16
Q7	2N3694	+5.0	+5.7	+12.2
Q8	2N3638	+4.5	+3.9	+0.41
Q9	2N3694	-6.7	-6.1	+3.9
Q10	2N3694	-6.7	-6.0	+0.41

TABLE 4-21. VOLTAGE MEASUREMENTS, AUXILIARY CONTROL A9

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3641	-3.0	-2.5	+7.7
Q2	2N3563	-8.5	-8.0	-3.2
Q3	2N3638	+10.4	+9.8	+3.0
Q4	2N3638	+9.8	+9.2	0
Q5	2N3641	-3.0	-2.5	+9.2
Q6	2N3641	-3.0	-2.5	+9.2
Q7	2N3638	+9.8	+9.2	0
Q8	2N3638	+10.4	+9.8	+3.0
Q9	2N3563	-8.5	-8.0	-3.2
Q10	2N3641	-3.0	-2.5	+7.7

SECTION V
SCHEMATIC DIAGRAMS

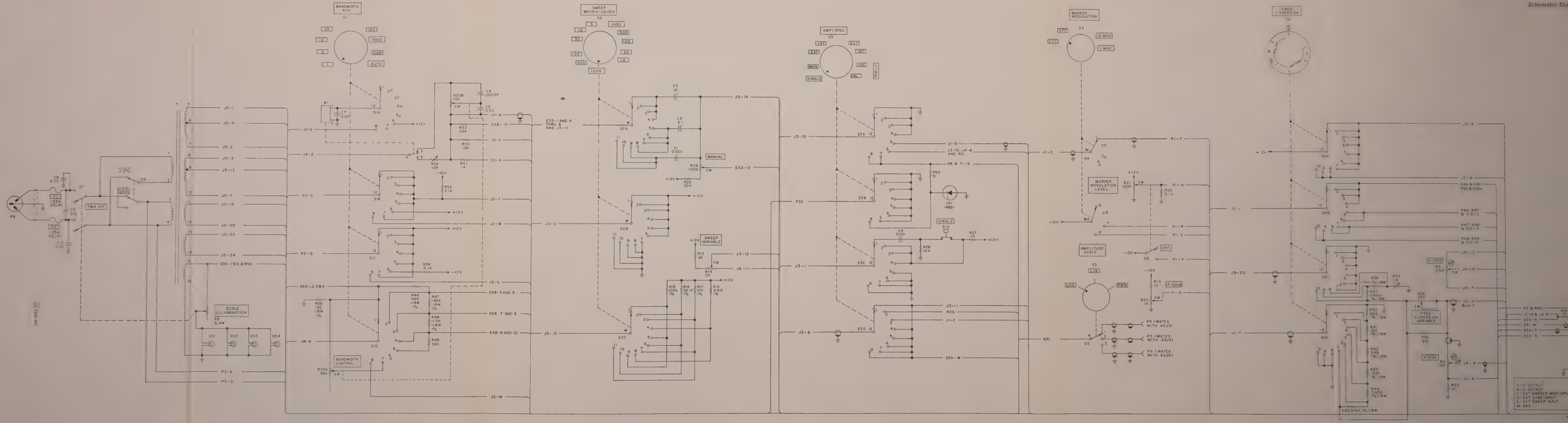


Figure 5-1. Model MF-100 Main Frame, Interconnecting Cabling Diagram (Sheet 1 of 2)

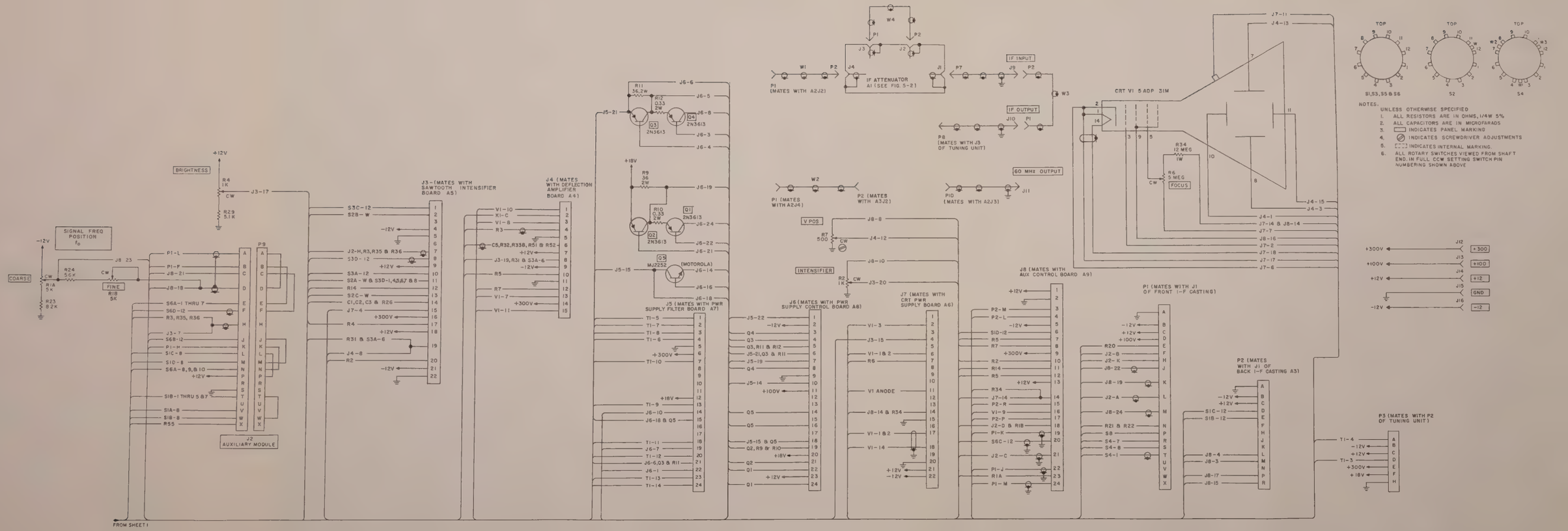


Figure 5-1. Model MF-100 Main Frame, Interconnecting Cabling Diagram (Sheet 2 of 2)

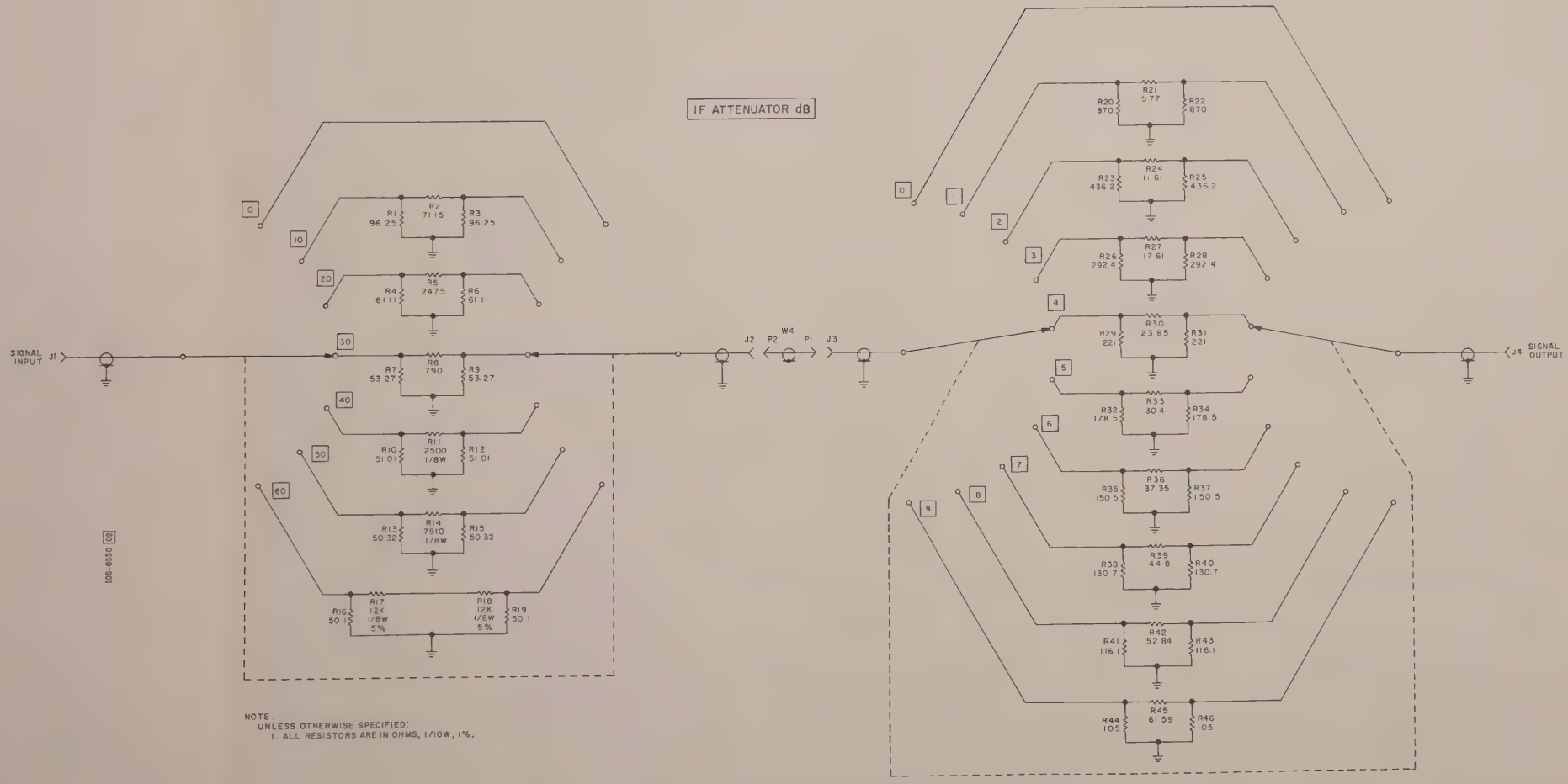


Figure 5-2. I-f Attenuator A1, Schematic Diagram

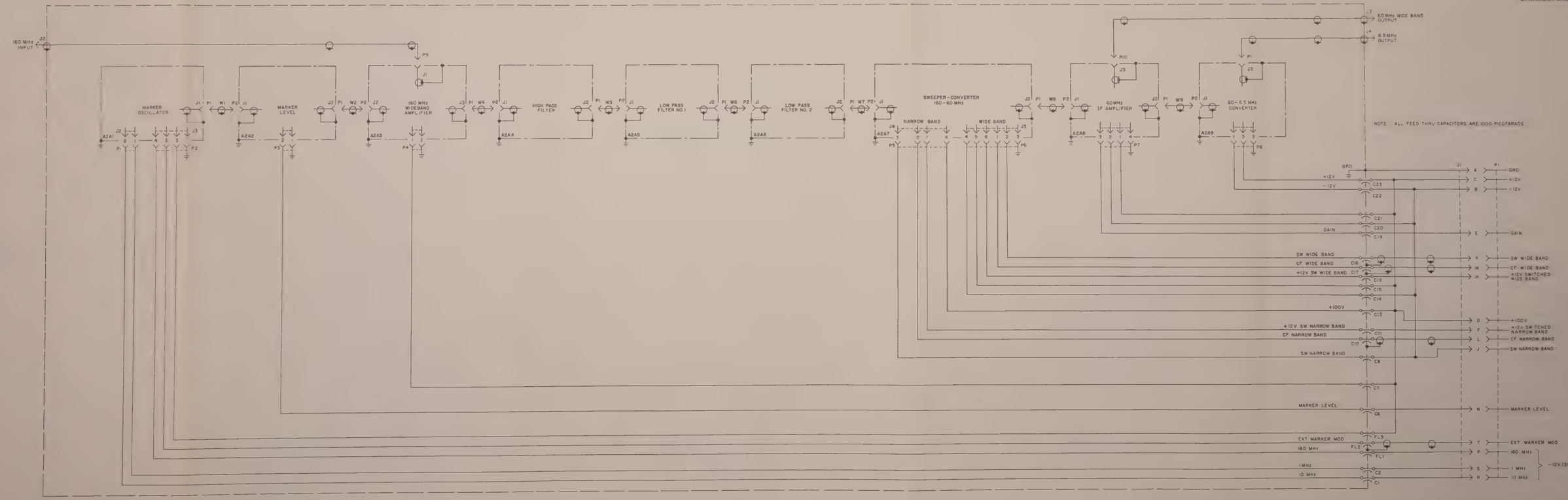
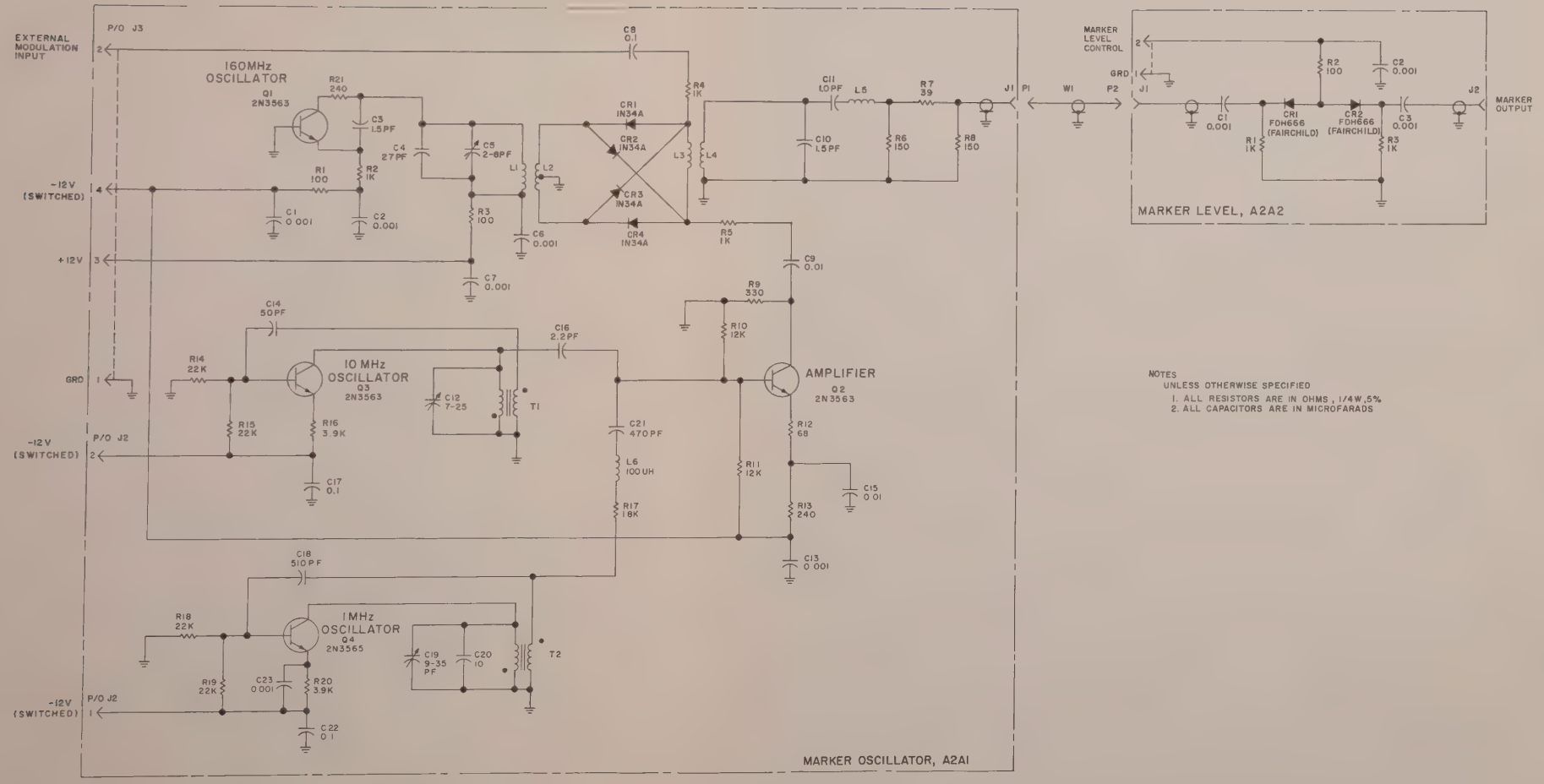


Figure 5-3. Front I-f Assembly A2, Interassembly Cabling Diagram



106-0633 [04]

Figure 5-4. Marker Oscillator A2A1 and Marker Leveler A2A2, Schematic Diagram

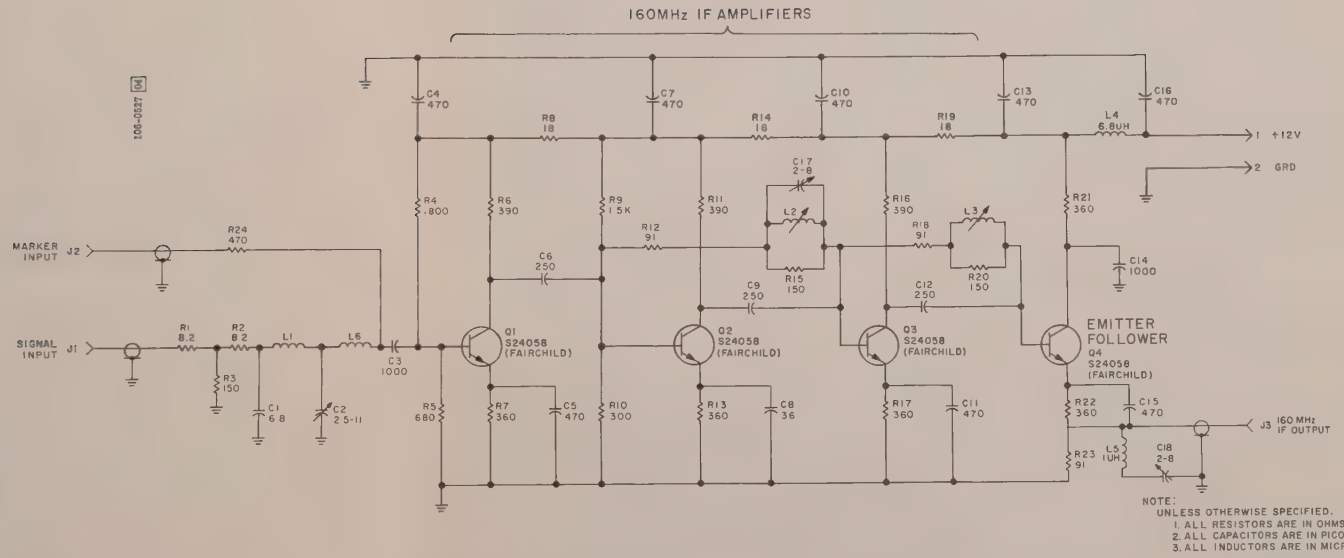
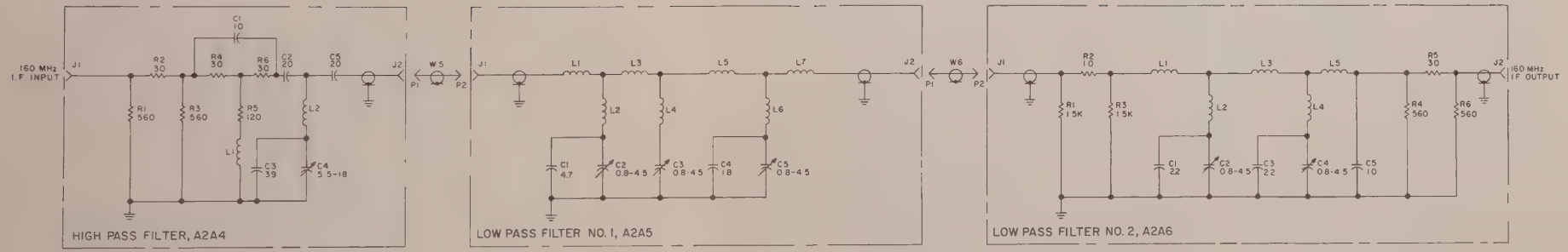


Figure 5-5. 160-MHz Wideband Amplifier A2A3, Schematic Diagram



108-0532 [01]

NOTES:
UNLESS OTHERWISE SPECIFIED,
1 ALL RESISTORS ARE IN OHMS, 1/4W, 5%
2 ALL CAPACITORS ARE IN PICOFARADS.

Figure 5-6. Highpass Filter A2A4 and Lowpass Filters A2A5 and A2A6, Schematic Diagram

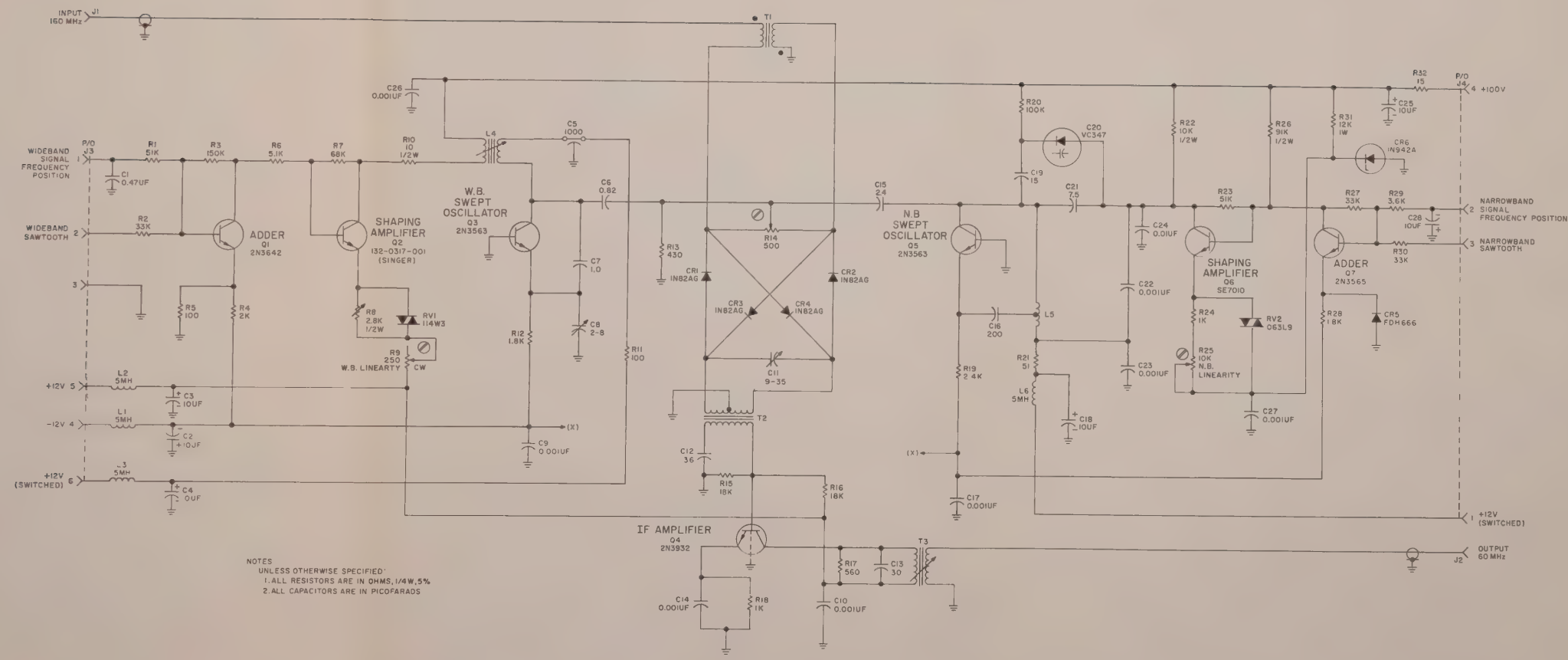


Figure 5-7. Swept Local Oscillator A2A7, Schematic Diagram

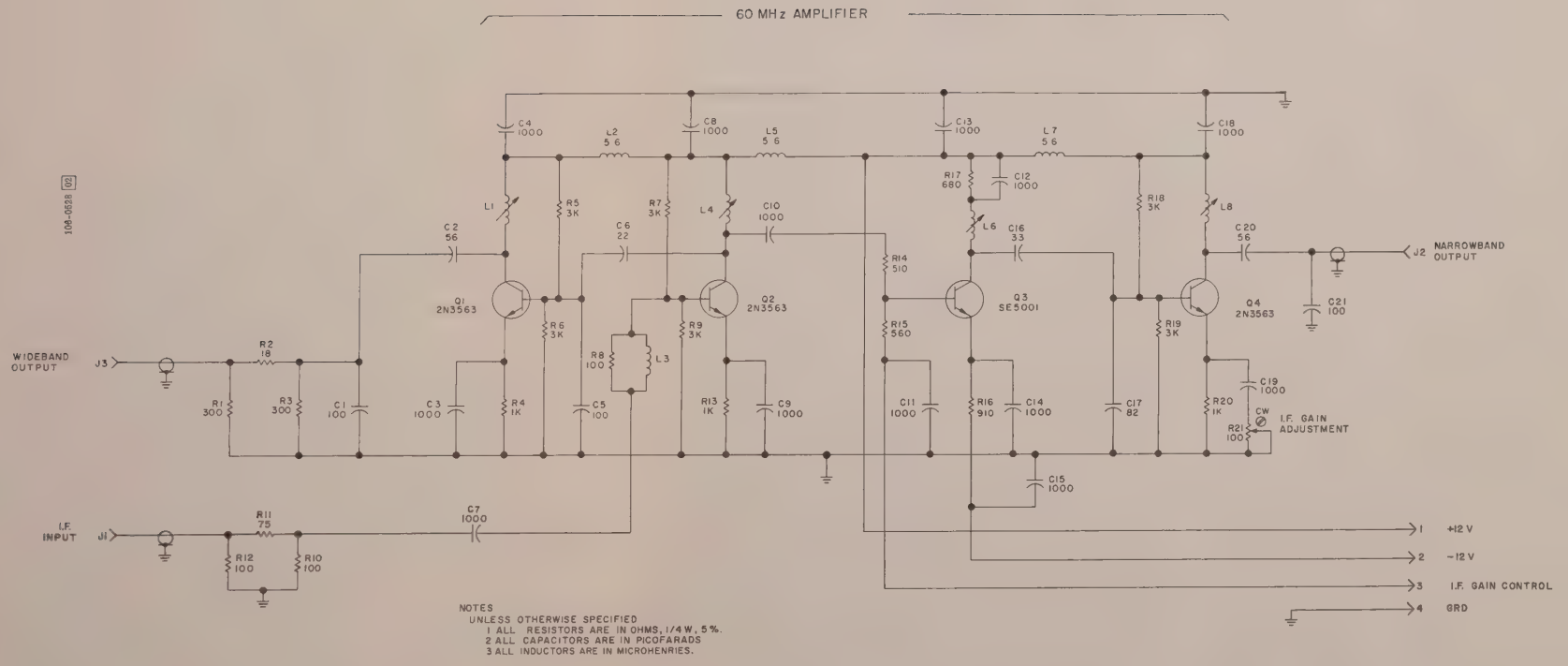
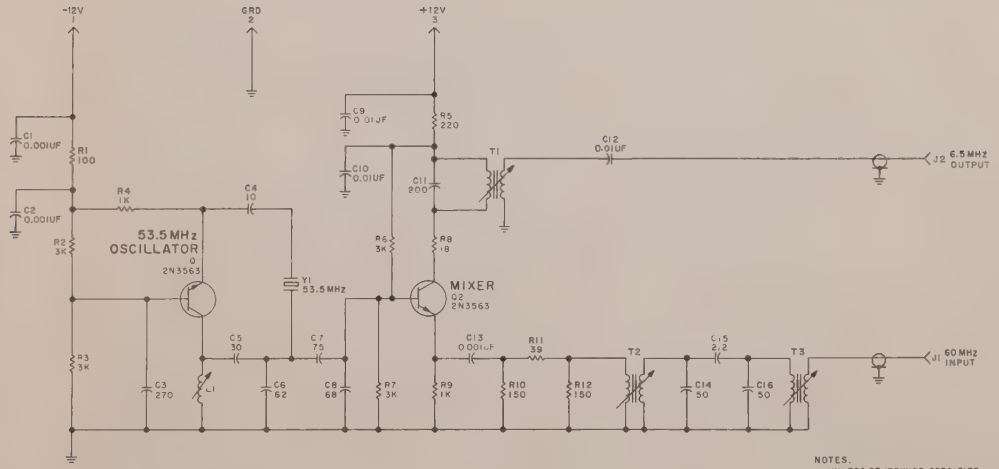


Figure 5-8. 60-MHz I-f Amplifier A2A8, Schematic Diagram



106-0328 [01]

Figure 5-9. 60/6.5-MHz Converter A2A9, Schematic Diagram

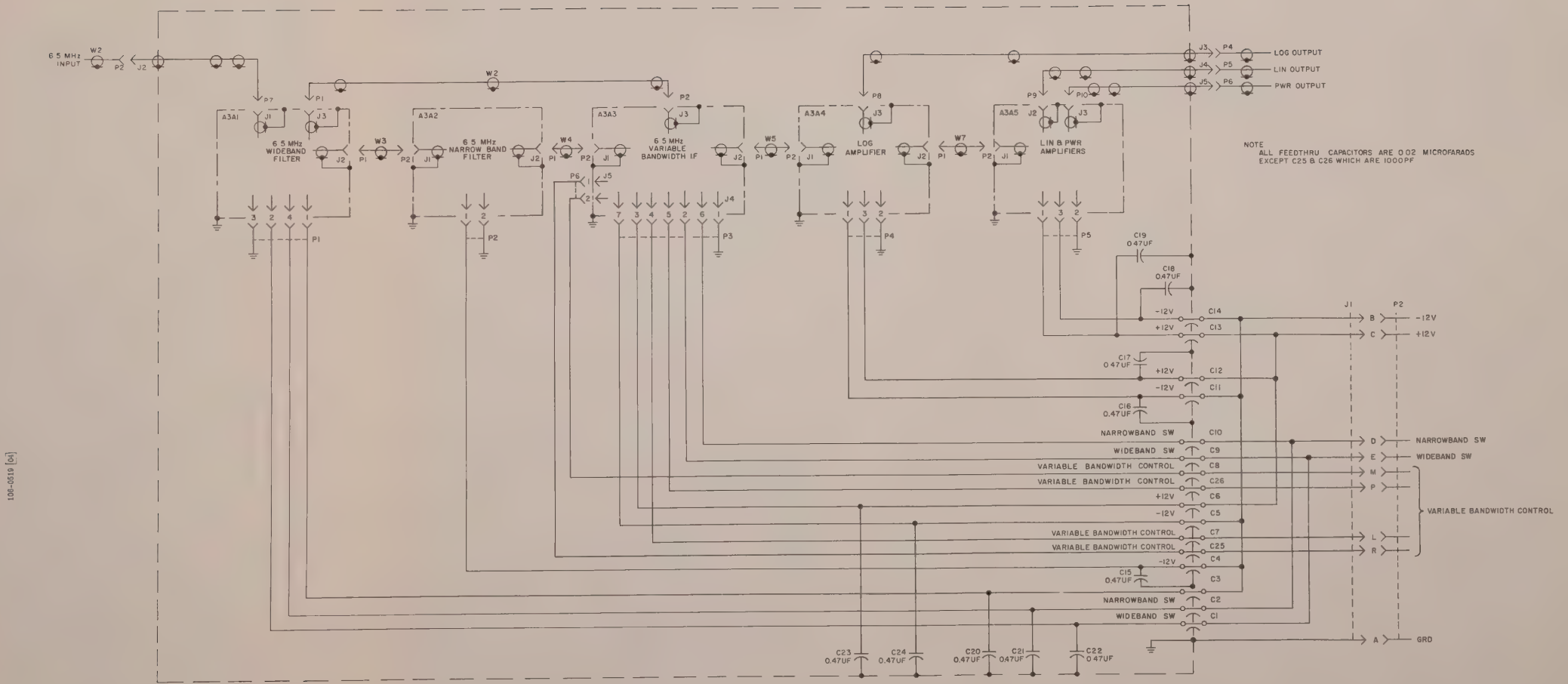


Figure 5-10. Back I-f Assembly A3, Interconnecting Cabling Diagram

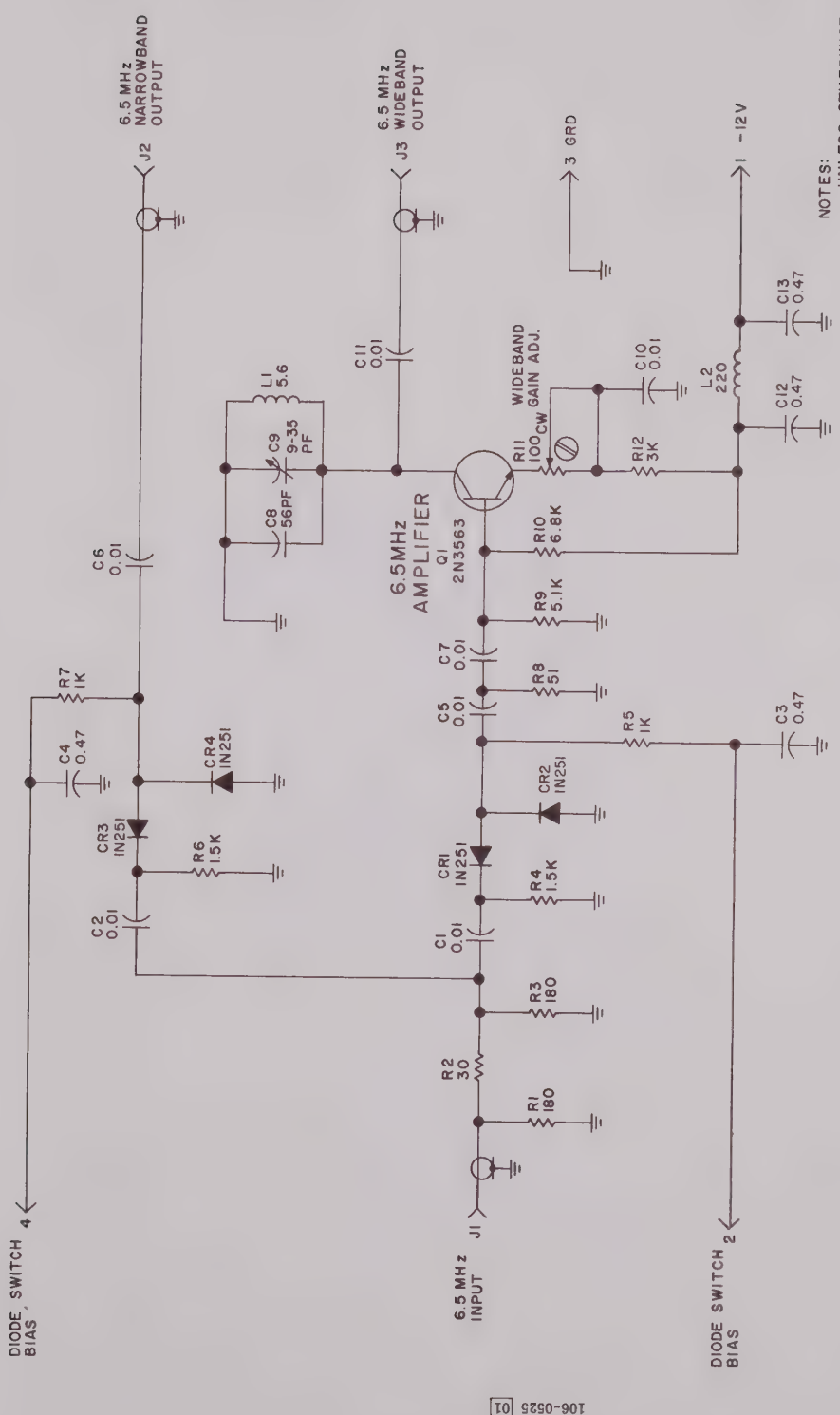
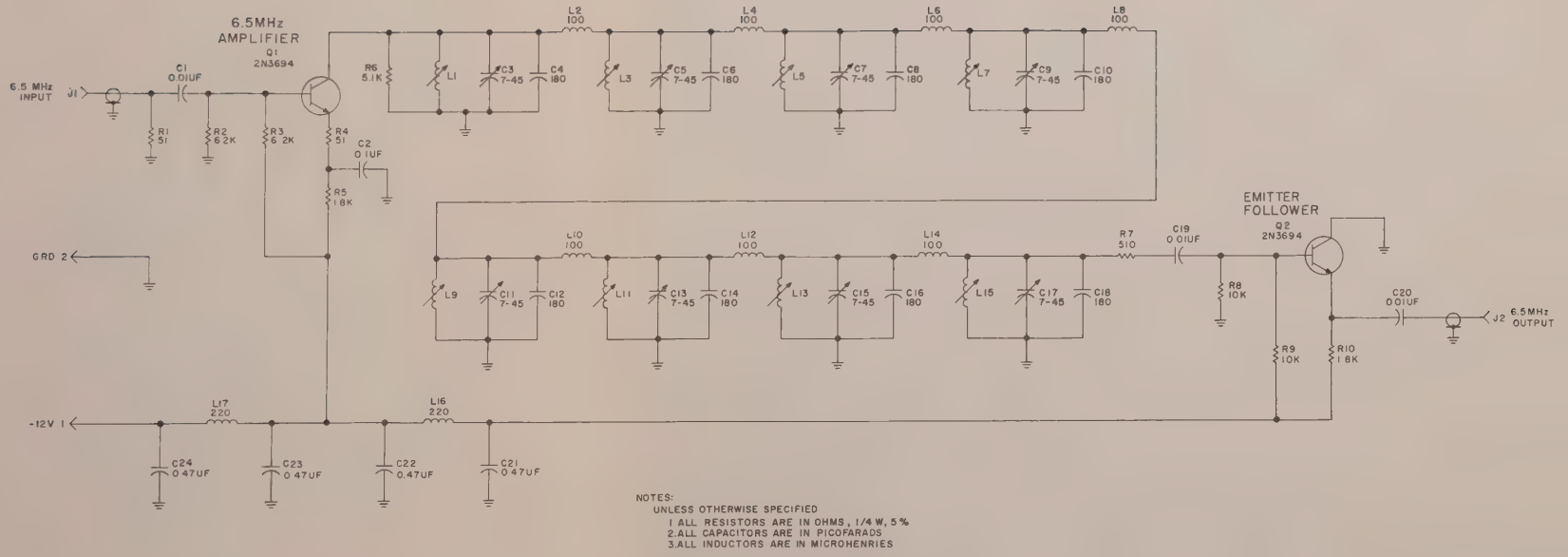


Figure 5-11. 6.5-MHz Wideband Filter A3A1, Schematic Diagram



NOTES:
UNLESS OTHERWISE SPECIFIED
1. ALL RESISTORS ARE IN OHMS, 1/4 W, 5%
2. ALL CAPACITORS ARE IN PICOFARADS
3. ALL INDUCTORS ARE IN MICROHENRIES

Figure 5-12. 6.5-MHz Narrowband Filter A3A2, Schematic Diagram

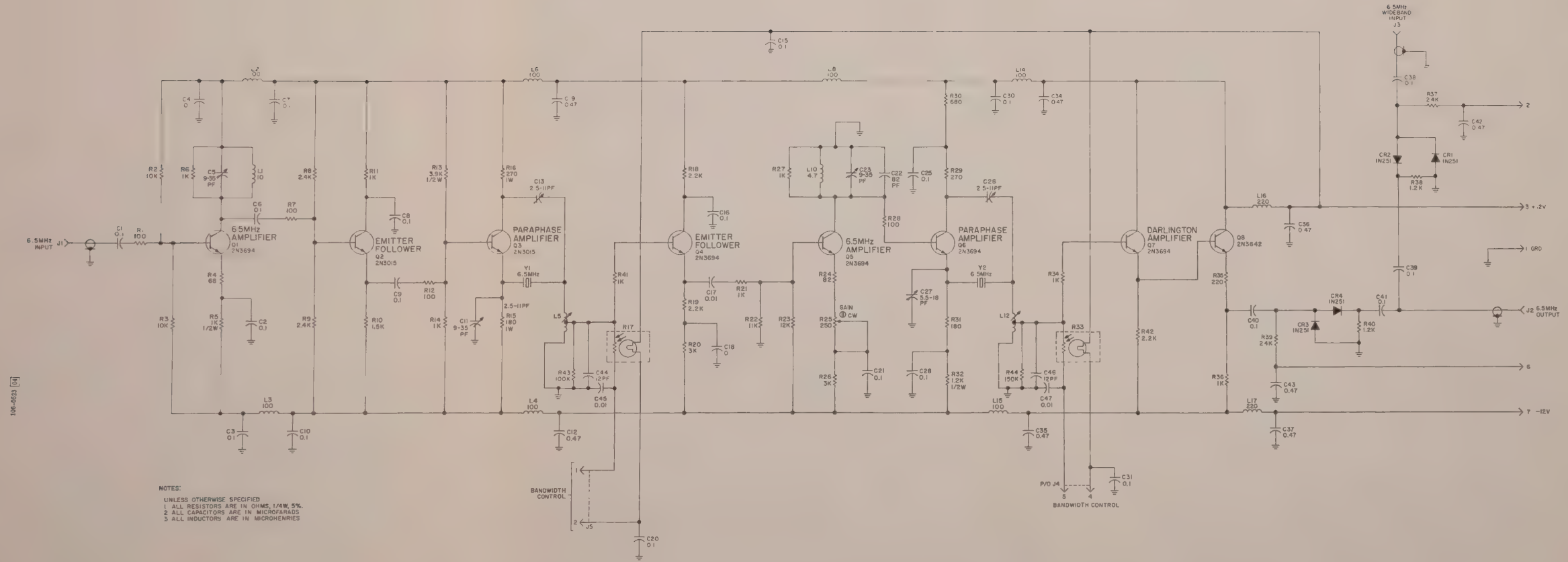


Figure 5-13. 6.5-MHz Variable Bandwidth Amplifier A3A3, Schematic Diagram

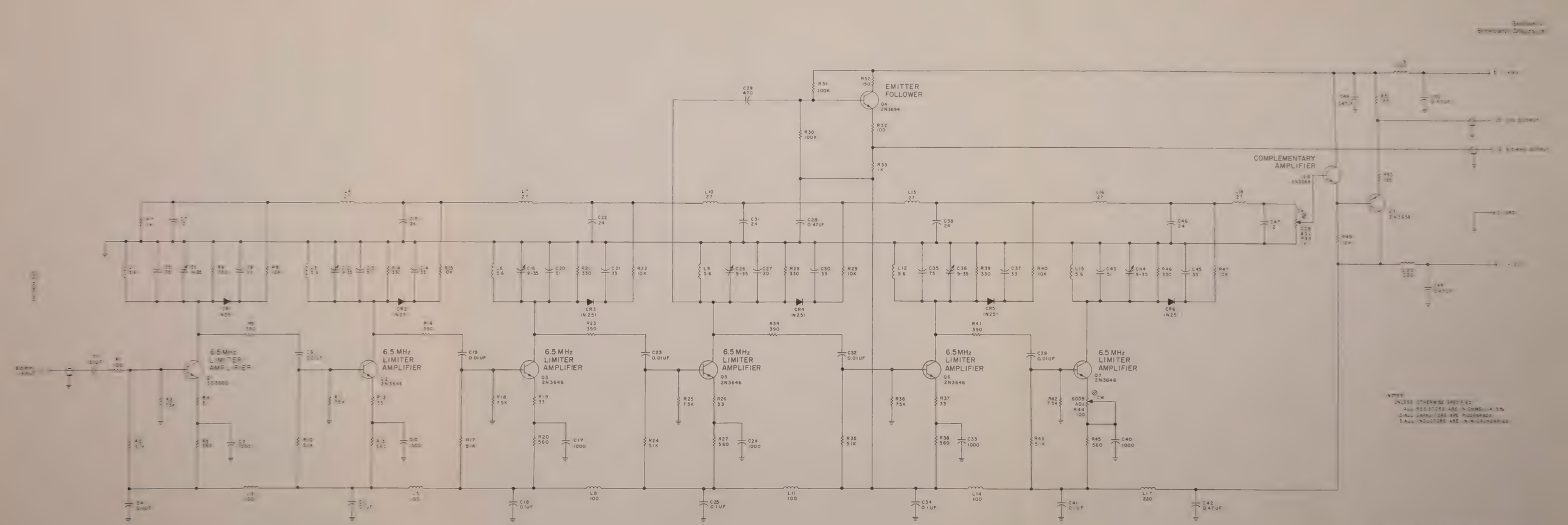
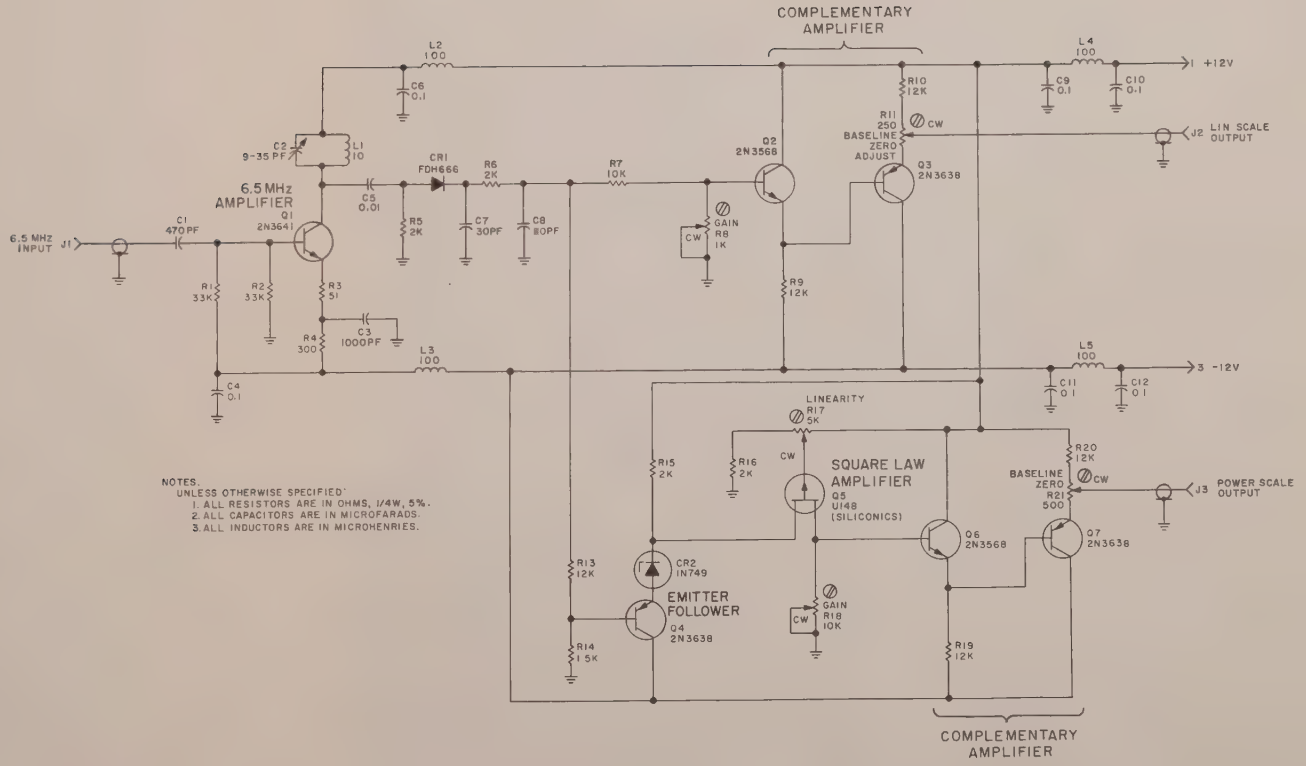


Figure 5-14. Log Amplifier A8A4, Schematic Diagram



NOTES.
UNLESS OTHERWISE SPECIFIED:
1. ALL RESISTORS ARE IN OHMS, 1/4W, 5%.
2. ALL CAPACITORS ARE IN MICROFARADS.
3. ALL INDUCTORS ARE IN MICROHENRIES.

106-0220 (2)

Figure 5-15. Lin/Power Amplifier A3A5, Schematic Diagram

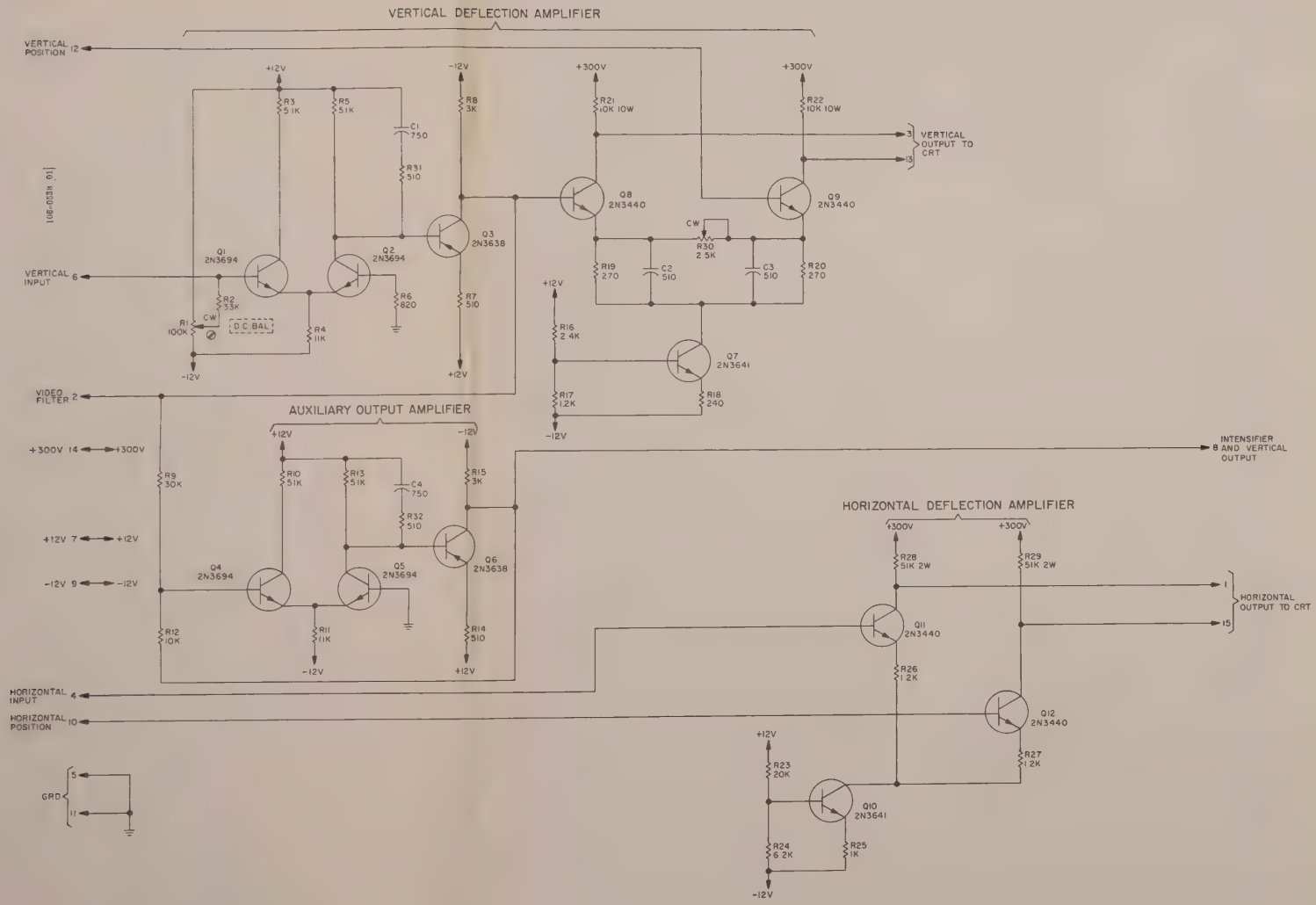


Figure 5-16. Deflection Amplifier A4, Schematic Diagram

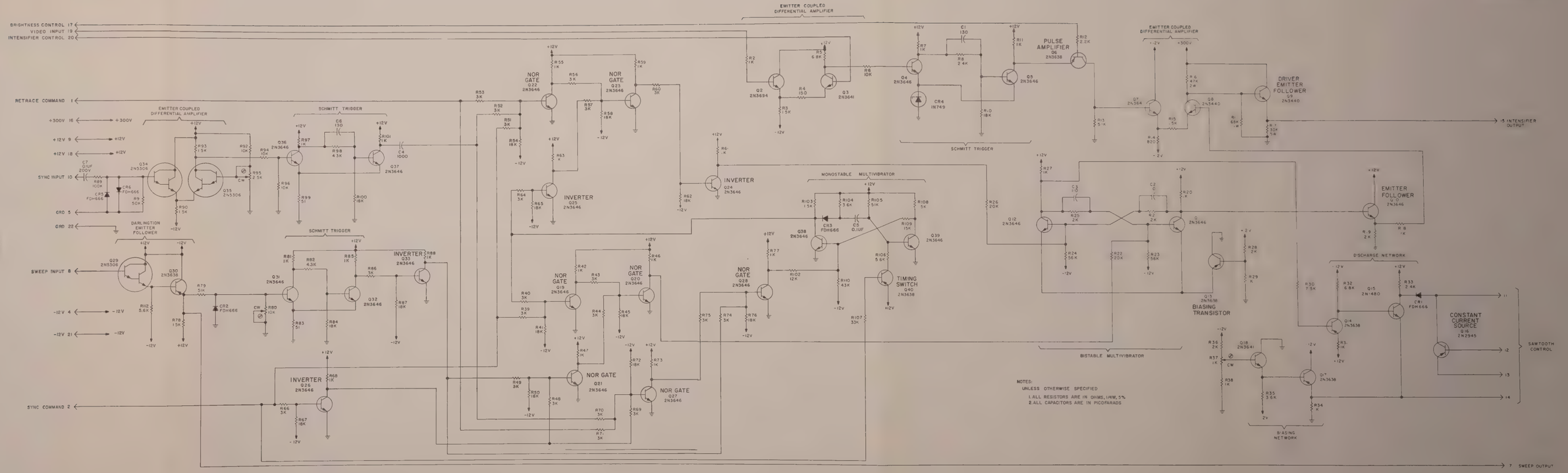


Figure 5-17. Sawtooth Intensifier A5, Schematic Diagram

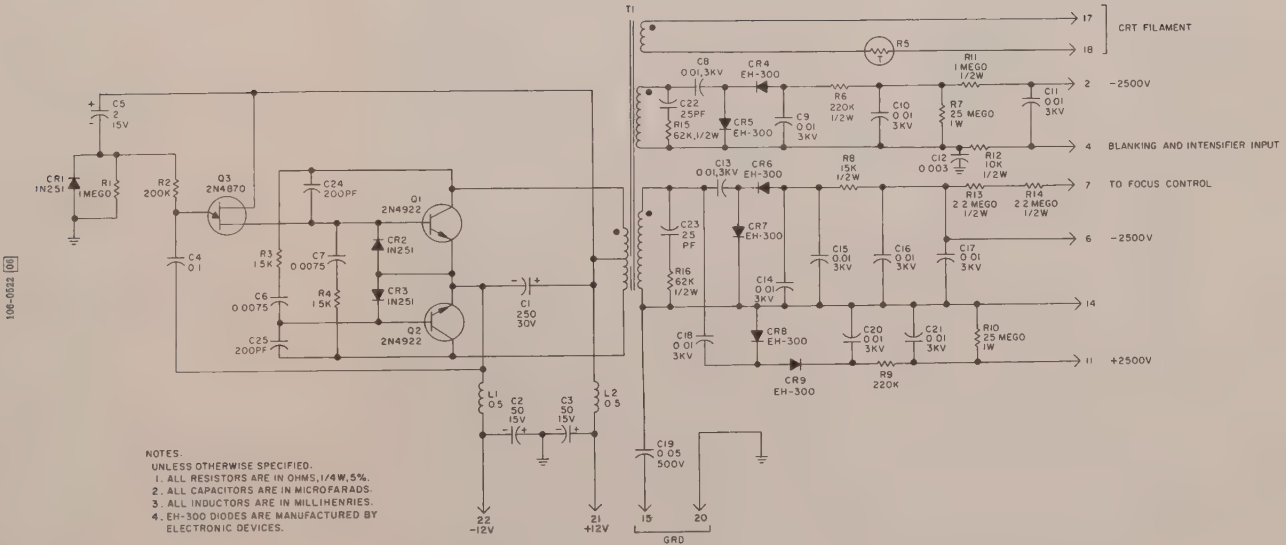


Figure 5-18. High Voltage Power Supply A6, Schematic Diagram

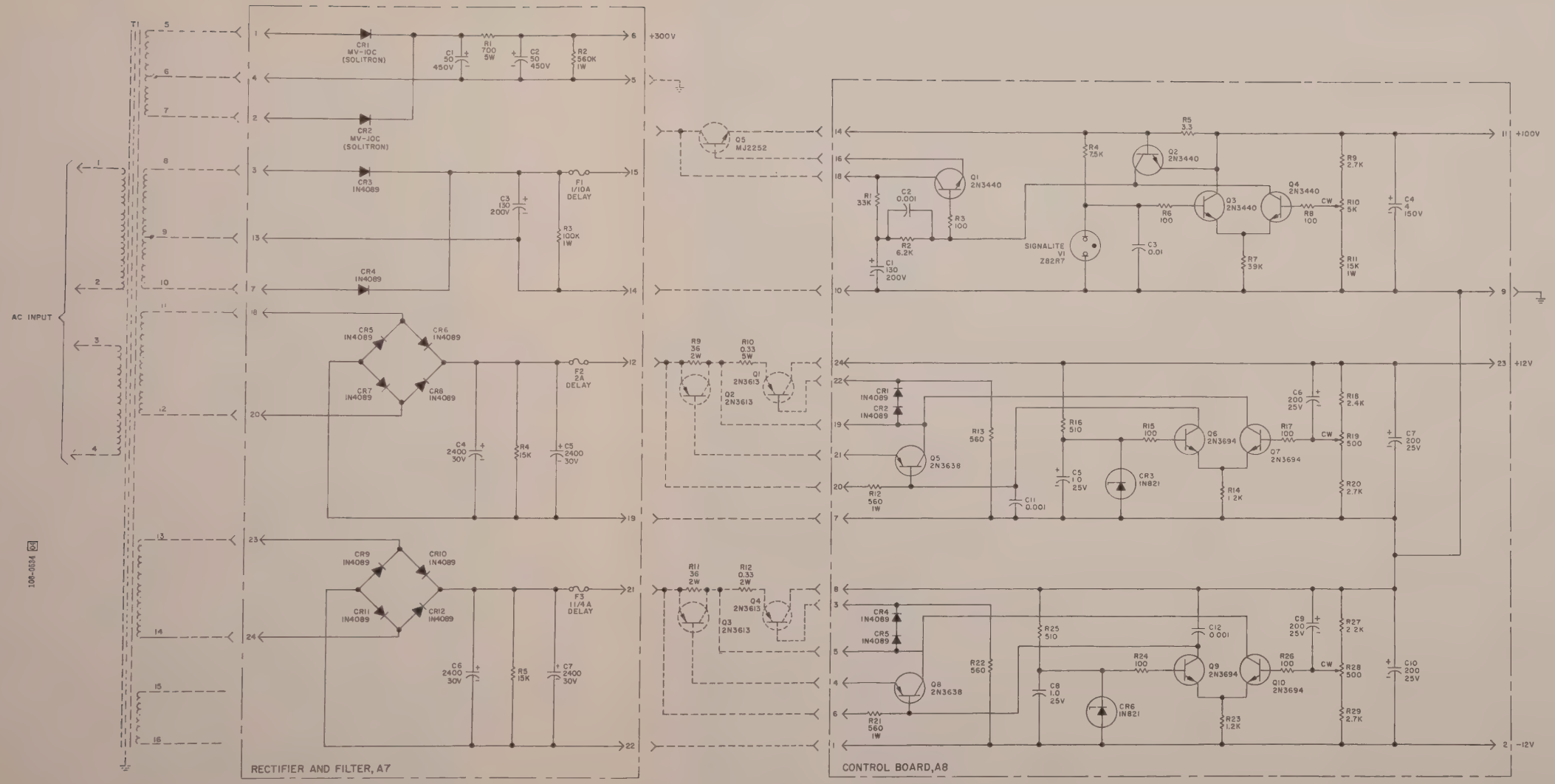
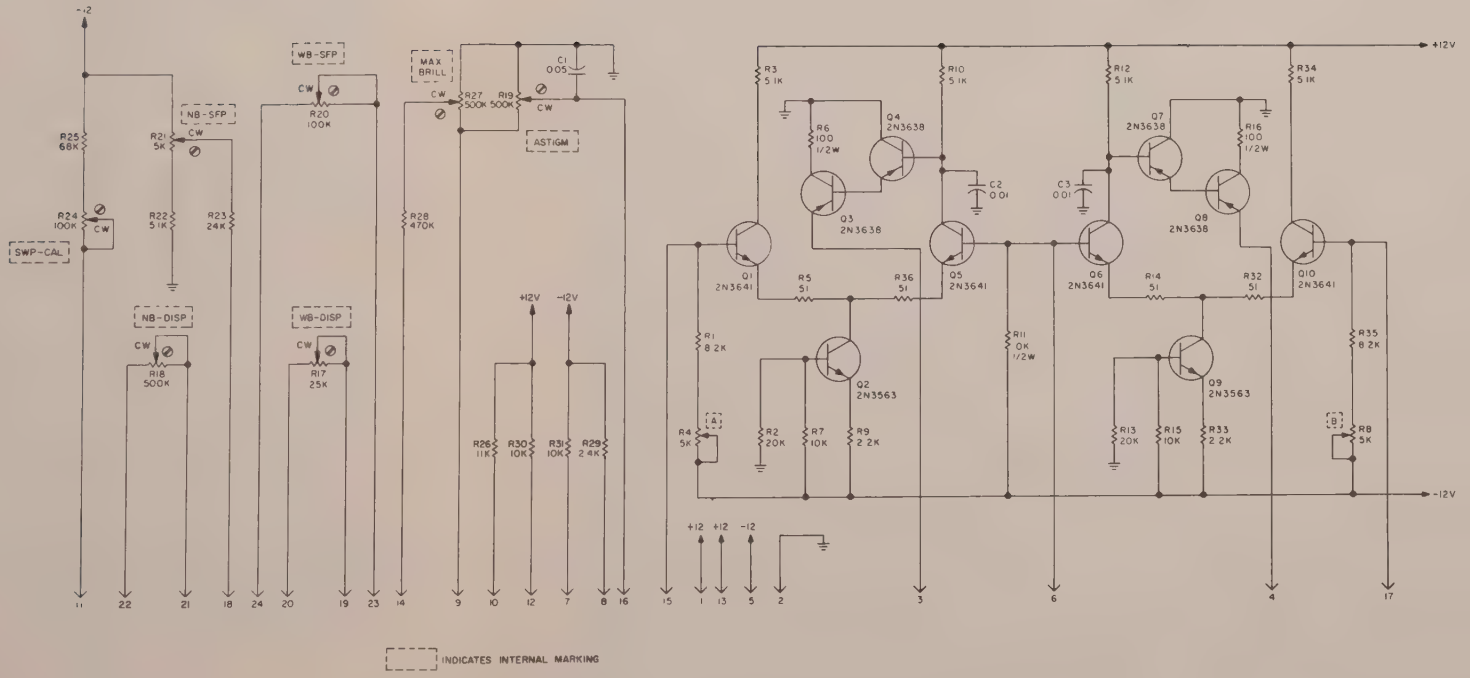


Figure 5-19. Power Supply Rectifier/Filter A7 and Power Supply Control A8, Schematic Diagram



INDICATES INTERNAL MARKING

NOTE UNLESS OTHERWISE SPECIFIED
ALL RESISTORS ARE IN OHMS, 1/4 W, 5%.
ALL CAPACITORS ARE IN MICROFARADS

Figure 5-20. Auxiliary Control A9, Schematic Diagram

SECTION VI
PARTS LIST

6-1. INTRODUCTION

6-2. This parts list section includes all pertinent data necessary to locate, identify, and procure additional parts for the equipment. Parts are listed alpha-numerically by reference symbol and include all replaceable items such as electronic, electro-mechanical, and mechanical parts of the equipment. In some cases, values, ratings and manufacturer sources shown are nominal and variations may be found. Satisfactory replacement may be made with either the listed component or an exact replacement of the part(s) removed from the equipment.

6-3. ORDERING INFORMATION

6-4. The following instructions will aid in ordering parts from the Parts Lists, tables 6-2 through 6-4.

a. Address all inquiries or orders to:

CUSTOMER SERVICE
Department 50
The Singer Company
Metrics Division
915 Pembroke Street
Bridgeport, Connecticut, 06608

b. Include the following information:

1) Model and Serial Number of instrument.

2) Singer Part Number.

3) Reference Symbol Number.

4) Description (as shown on list).

6-5. HOW TO USE THE PARTS LIST

6-6. Paragraphs 6-7 through 6-11 describe the use and meaning of the five columns included in the parts list (see figure 6-1).

6-7. REF SYMBOL COLUMN. The Ref Symbol Column (1, figure 6-1) contains an alpha-numerical listing of parts as they appear on equipment chassis, illustration, or schematic. The reference designation identifies the parts as to their component function in the instrument.

6-8. DESCRIPTION COLUMN. The Description Column (2, figure 6-1) contains the identification of component parts including all pertinent specifications and Singer part number. When the description column is used for a part which is identical to a part which has already been described; SAME AS (3) is used along with the reference symbol of the previously used part. In these instances, columns 3, 4, 5 are left blank. When the description column is used for a reference symbol for which no part exists; NOT USED (4) is placed in the column. In these instances, columns 3, 4, 5, are left blank.

6-9. MANUFACTURER'S PART NUMBER COLUMN. The Manufacturer's Part Number column (5, figure 6-1) contains the part number as designated by the manufacturer of the part.

6-10. MFR'S CODE COLUMN. The Mfr's Code column (6, figure 6-1) references the manufacturer by an assigned code number as listed in Federal Supply Code Handbook H4-2. For manufacturers not listed in H4-2, a letter code will be assigned. Table 6-1 includes the manufacturer and his code designation.

6-11. MAINT QTY COLUMN. The Maint Qty column (7, figure 6-1) contains the number of additional components recommended to keep the equipment at an optimum performance level. The recommended number of components in the Maint Qty column is based on 2000 hours of equipment operation.

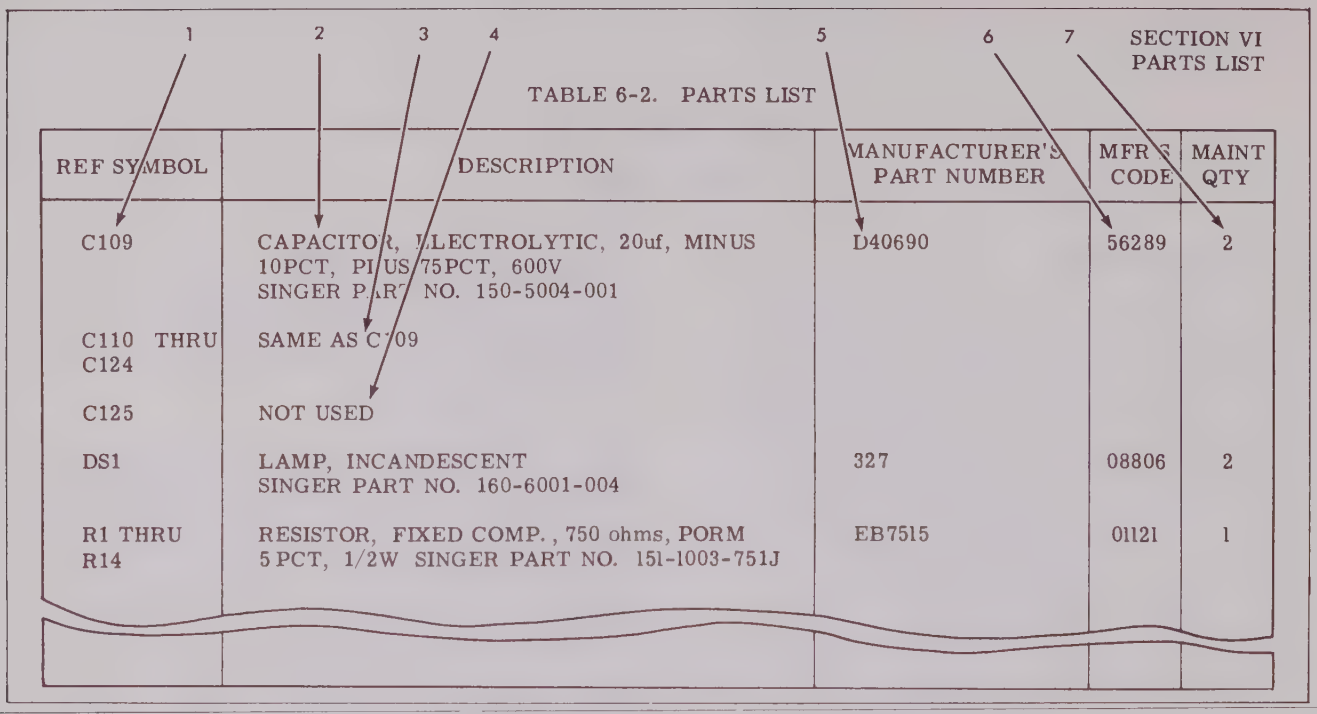


Figure 6-1. Parts List Sample

TABLE 6-1. MANUFACTURER'S CODE

Number	Name
00656	Aerovox Corp. New Bedford, Mass.
01121	Allen-Bradley Co. Milwaukee, Wisc.
02660	Amphenol-Borg Electronic Corp. Maywood, Ill.
02799	Arco Capacitors, Inc. Los Angeles, Calif.
04213	Caddell-Burns Mfg. Co. Mineola, N.Y.
04713	Motorola Inc. Semiconductor Products Division Pheonix, Arizona
07263	Fairchild Camera and Instrument Corp. Semiconductor Division Mountain View, Calif.
10646	The Carborundum Co. Niagara Falls, N.Y.
11236	CTC of Berne Inc. Berne, Ind.
12126	Kidco Inc. Medford, N.J.

Number	Name
12697	Clarostat Mfg. Co., Inc. Dover, N.H.
13327	Solitron Devices Inc. Tappan, N.Y.
14936	General Instrument Corp. Semi-Conductor Division Hicksville, Long Island, N.Y.
16665	The Singer Company Metrics Division Bridgeport, Conn.
17856	Siliconix Inc. Sunnyvale, Calif.
18736	Voltronic Corp. Hanover, N.J.
19373	Eastron Corp. Haverhill, Mass.
25088	Siemen America Inc. New York, N.Y.
56289	Sprague Electric Co. North Adams, Mass.
63743	Ward Leonard Electric Co. Mount Vernon, N.Y.

TABLE 6-1. MANUFACTURER'S CODE (Cont'd)

Number	Name
71400	Bussmann Mfg. Division of McGraw Edison Company St. Louis, Mo.
71590	Centralab Division of Gloge-Union Inc. Milwaukee, Wisc.
71785	Cinch Mfg. Co. and H.B. Jones Division Chicago, Ill.
72136	Electro-Motive Mfg. Co., Inc. Willimantic, Conn.
72982	Erie Technological Products Inc. Erie, Pa.
74276	Signalite Inc. Neptune, N.J.
74970	E.F. Johnson Co. Waseca, Minn.
75042	International Resistance Co. Philadelphia, Pa.
75915	Littelfuse Inc. Des Plaines, Ill.
78488	Stackpole Carbon Co. St. Marys, Pa.
78526	Stanwyck Winding Co., Inc. Newburgh, N.Y.
81073	Grayhill Inc. La Grange, Ill.
81349	Military Specifications
81483	International Rectifier Corp. El Segundo, Calif.
82389	Switchcraft Inc. Chicago, Ill.
83186	Victory Engineering Corp. Springfield, N.J.
83330	Herman H. Smith, Brooklyn, N.Y.
83701	Electronic Devices Inc. Yonkers, N.Y.
91506	Augat Inc. Attleboro, Mass.
91637	Dale Electronics Inc. Columbus, Nebr.
91833	Keyston Electronics Corp, N.Y., N.Y.
92966	Hudson Lamp Co. Kearny, N.J.
93332	Sylvania Electric Products Inc. Semiconductor Products Division Woburn, Mass.
94144	Raytheon Co. Components Division Quincy, Mass.
95073	Douglas Randall Inc. Westerly, R.I.
95238	Continental Connector Corp. Woodside, N.Y.
95354	Methode Mfg. Co. Chicago, Ill.
98291	Sealectro Corp. Mamaroneck, N.Y.
99517	Vacco Industries El Monte, Calif.
99800	Delevan Electronics Corp. East Aurora, N.Y.

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
CR1	SEMICONDUCTOR DEVICE.DIODE SINGER PART NO. 556146-688	2N821	81349	1
C1	CAPACITOR,FIXED,CERAMIC, 0.001 UF,PORM 10 PCT,1000V SINGER PART NO. 556060-046	DD-102	71590	5
C2	CAPACITOR,FIXED METALIZED PLASTIC, 0.10 UF, PORM 10 PCT,250V SINGER PART NO. 556146-921	B32231-A3104K	25088	1
C3	CAPACITOR,FIXED,METALIZED PLASTIC, 10 UF, PORM 20 PCT, 50V SINGER PART NO. 556146-920	B32110-C9106M	25088	1
C4	SAME AS C1			
C5	CAPACITOR,FIXED,CERAMIC,DISC, 0.02 UF,PORM 20 PCT,1000V SINGER PART NO. 556146-932	CCD-203	02799	1
C6	CAPACITOR,FIXED,DIPPED MICA, 200PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-201EJO	DM15E201J/500WV4CR	72136	1
C7 AND C8	CAPACITOR,FIXED,METALLIZED PAPER, 0.05 UF, PORM 20 PCT,600WVDC SINGER PART NO. 556074-059	P8292ZN27	00656	1
C9	CAPACITOR,FIXED,CERAMIC DISC, 0.01 UF,PORM 20 PCT,3000VDC SINGER PART NO. 150-1006-001	41C121A2	56289	1
C10	SAME AS C7			
DS1 THRU DS4	LAMP,INCANDESCENT,6.3V SINGER PART NO. 160-6001-002	349	92966	6
E1	CONNECTOR,SECOND ANODE SINGER PART NO. 556023-079	3A1	71785	1
F1 AND F2	FUSE,DELAY, 1 1/4 AMPS SINGER PART NO. 556146-743	MDL1 1/4	71400	8
J1	CONNECTOR,JACK SINGER PART NO. 556146-751	SM11-20SGD	95238	1
J2	CONNECTOR,JACK SINGER PART NO. 556146-755	SM20-20SGD	95238	1
J3	CONNECTOR,JACK, 22 CONTACTS SINGER PART NO. 168-3002-007	71-6022-1100-00	95354	1
J4	CONNECTOR,PRINTED CIRCUIT SINGER PART NO. 168-3002-005	CD615S	95354	1
J5 AND J6	CONNECTOR,JACK SINGER PART NO. 168-3002-008	71-6024-1107-00	95354	1
J7	SAME AS J3			
J8	SAME AS J5			
J9 THRU J11	CONNECTOR,JACK SINGER PART NO. 556147-018	50-010-0000	98291	1
J12 THRU J14	JACK,TIP RED,SINGER PART NO. 556146-912	105-602	74970	1
J15	JACK,TIP BLACK,SINGER PART NO. 556146-913	105-603	74970	1
J16	JACK,TIP VIOLET,SINGER PART NO. 556146-914	105-612	74970	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
K1	RELAY,REED SINGER PART NO. 556146-594	12MM-1C	95073	1
P1	SAME AS J2			
P2	CONNECTOR,PLUG SINGER PART NO. 556146-753	SM14-20SGD	95238	1
P3	CONNECTOR,PLUG, 7 CONTACTS SINGER PART NO. 556016-185	126-196	02660	1
P4 THRU P6	CONNECTOR,COAXIAL SINGER PART NO.556205-007	51-011-0000	98291	1
P7	CONNECTOR,PLUG SINGER PART NO. 556147-021	58-007-0000	98291	1
P8	CONNECTOR,PLUG SINGER PART NO. 556147-020	59-007-0000	98291	1
P9	CONNECOTR,PLUG SINGER PART NO. 556146-754	SM20-20PGD	95238	1
P10	CONNECTOR,PLUG, SINGER PART NO. 168-4031-001	51-007-0000	98291	1
Q1 THRU Q4	TRANSISTOR SINGER PART NO. 556146-678	2N3613	81349	1
Q5	TRANSISTOR SINGER PART NO. 556146-685	MJ2252	04713	1
R1	RESISTOR,VARIABLE,DUAL CONCENTRIC,5K/5K OHMS	132-0268-001	16665	1
R2	RESISTOR,VARIABLE, 1000 OHMS,PORM 10 PCT,2W SINGER PART NO. 151-0007-063	91410	01121	1
R3	RESISTOR,VARIABLE, 10K OHMS,PORM 10 PCT,1/2W SINGER PART NO. 151-0001-055	GA1N044S103UA	01121	1
R4	SAME AS R2			
R5	RESISTOR,VARIABLE, 2.5K OHMS,PORM 20 PCT, 1/2W SINGER PART NO. 151-0001-054	GAIN044S252MA	01121	1
R6	RESISTOR,VARIABLE, 5 MEGOHMS,PORM 10 PCT,2W	149-0069-001	16665	1
R7	RESISTOR,VARIABLE, 500 OHMS,PORM 20 PCT,1/2W SINGER PART NO. 151-0001-053	GAIN044S501MA	01121	1
R8	RESISTOR,VARIABLE, 6 OHMS,PORM 10 PCT, 4W, WITH SWITCH ATTACHED SINGER PART NO. 151-0017-002	CM37449	12697	1
R9	RESISTOR,FIXED,COMP.,36OHMS,2W PORM 5PCT SINGER PART NO. 151-1005-360J	HB3605	01121	1
R10	RESISTOR,FIXED,WIRE-WOUND, 0.33 OHMS,PORM 10 PCT,2W SINGER PART NO. 556146-922	BWH-0.330HMPORM10PCT	75042	1
R11	SAME AS R9			
R12	SAME AS R10			
R13	RESISTOR,FIXED,COMP., 3000 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-302J	CB3025	01121	5
R14	PART OF S3			
R15	RESISTOR,FIXED,DEPOSITED CARBON, 3.01K OHMS, PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B3011F	C1/8E3010OHMPORM1PCT	12126	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
R16	RESISTOR,FIXED,DEPOSITED CARBON, 30.1K OHMS, PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B3012F	C1/8E30100 PORM1PCT	12126	1
R17	RESISTOR,FIXED,DEPOSITED CARBON, 10 K OHMS, PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B1002F	C1/8R10KOHMPORM1PCT	12126	1
R18	RESISTOR,FIXED,DEPOSITED CARBON, 100K OHMS, PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B1003F	C1/8E104OHMPORM1PCT	12126	1
R19	RESISTOR,FIXED,COMP.,1000 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-102J	CB1025	01121	8
R20	PART OF S5			
R21	PART OF S4			
R22	RESISTOR,FIXED,COMP., 5100 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-512J	CB5125	01121	4
R23	RESISTOR,FIXED,COMP., 8200 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-822J	CB8225	01121	1
R24	RESISTOR,FIXED,COMP., 56K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-563J	CB5635	01121	2
R25	RESISTOR,FIXED,COMP., 30K OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-303J	CB3035	01121	1
R26	PART OF S2			
R27	SAME AS R19			
R28	RESISTOR,FIXED,COMP., 10K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-103J	CB1035	01121	3
R29	SAME AS R22			
R30 AND R31	SAME AS R19			
R32	RESISTOR,FIXED,COMP., 33K OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-333J	CB3335	01121	2
R33A AND R33B	PART OF S1			
R34	RESISTOR,FIXED,WIRE-WOUND, 12 MEGOHM,PORM 20 PCT,1W SINGER PART NO. 556146-910	MVX/12MEGPORM20PCT1W	75042	1
R35	RESISTOR,FIXED,COMP., 51K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-513J	CB5135	01121	2
R36	PART OF S6			
R37	RESISTOR,FIXED,DEPOSITED CARBON, 5490 OHMS PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B5491F	C1/8E5490OHMPORM1PCT	12126	1
R38	RESISTOR,FIXED,DEPOSITED CARBON, 1740 OHMS, PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B1741F	C1/8E1740OHMPORM1PCT	12126	1
R39	RESISTOR,VARIABLE, 800 OHMS TO 1.2K OHMS SINGER PART NO. 556147-193	VR025-1001	99517	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
R40	RESISTOR,FIXED,DEPOSITED CARBON, 49.9 OHMS PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B49R9F	C1/8E49.9OHMPORM1PCT	12126	1
R41	RESISTOR,FIXED,DEPOSITED CARBON, 100 OHMS, PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B1000F	C1/8E100OHMPORM1PCT	12126	1
R42	RESISTOR,FIXED,DEPOSITED CARBON, 348 OHMS, PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B3480F	C1/8E348OHMPORM1PCT	12126	1
R43	RESISTOR,FIXED,DEPOSITED CARBON, 1020 OHMS, PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B1021F	C1/8E1020OHMPORM1PCT	12126	1
R44	RESISTOR,FIXED,DEPOSITED CARBON, 3650 OHMS PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B3651F	C1/8E3650OHMPORM1PCT	12126	1
R45	RESISTOR,FIXED,DEPOSITED CARBON, 9760 OHMS, PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B9761F	C1/8E9760OHMPORM1PCT	12126	1
R46	RESISTOR,FIXED,DEPOSITED CARBON, 499 OHMS, PORM 1 PCT,1/4W SINGER PART NO. 151-1006-B4990F	C1/8E499PORM1PCT	12126	1
R47	RESISTOR,FIXED,DEPOSITED CARBON, 1.82 KOHMS, PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B1821F	C1/8E1820PORM1PCT	12126	1
R48	RESISTOR,FIXED,DEPOSITED CARBON, 11.5 KOHMS, PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B1152F	C1/8E11500PORM1PCT	12126	1
R49	RESISTOR,FIXED,COMP., 39 KOHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-393J	CB3935	01121	1
R50	RESISTOR,FIXED,COMP., 51 OHMS,PORM 5 PCT 1/4W SINGER PART NO. 151-1002-510J	CB5105	01121	2
R51	SAME AS R19			
R52	RESISTOR,VARIABLE, 8K TO 12K, 1/4W SINGER PART NO. 556147-063	VR025-1002	99517	1
R53 AND R54	SAME AS R22			
R55	RESISTOR,FIXED,COMP.,15KOHMS,PORM 5PCT., 1/4W SINGER PART NO. 151-1002-153J	CB1535	01121	1
R56	RESISTOR,FIXED,DEPOSITED CARBON, 150 OHMS, PORM 1 PCT,1/4W SINGER PART NO. 151-1006-B1500F	C1/8E150PORM1PCT	12126	1
S1	SWITCH AND POT ASSY, BANDWIDTH	133-0107-001	16665	1
S2	SWITCH AND POT ASSY SWEEP	133-0089-001	16665	1
S3	SWITCH AND POT ASSY SWP/SYNC	133-0088-001	16665	1
S4	SWITCH AND POT ASSY MARKER MODULATION	133-0073-001	16665	1
S5	SWITCH AND POT ASSY AMPLSCALE	133-0077-001	16665	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
S6	SWITCH AND POT ASSY FREQ DISPERSION	133-0083-001	16665	1
S7	SWITCH,NON-REPLACEABLE PART OF R8			
S9	SWITCH,SLIDE, DPDT SINGER PART NO. 556146-590	46206LF	82389	1
S10	SWITCH,PUSH BUTTON,SPST SINGER PART NO. 556146-736	30-1	81073	1
T1	TRANSFORMER,POWER	132-0201-001	16665	1
V1	TUBE,CRT SINGER PART NO. 556146-902	5ADP31M	81349	1
W1	CABLE ASSY	102-9200-320	16665	1
W1P1	SAME AS P7			
W1P2	SAME AS P10			
W2	CABLE ASSEMBLY	102-9111-011	16665	1
W2P1 AND P2	SAME AS P10			
W3	CABLE ASSY	102-9200-360	16665	1
W3P1 AND P2	CONNECTOR,PLUG SINGER PART NO. 556147-019	50-011-0000	98291	1
W4	CABLE ASSEMBLY	102-9200-370	16665	1
W4P1 AND P2	SAME AS P7			
XF1 AND XF2	HOLDER,FUSE SINGER PART NO. 556006-072	341001	75915	1
XV1	SOCKET,TUBE	556024-047	16665	1
A1	I-F ATTENUATOR ASSY	103-1587-001	16665	1
A1J1 THRU J4	CONNECTOR ASSY	133-0070-001	16665	1
A1R1	RESISTOR,FIXED,FILM, 96.25OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-016	DC1/10-96.25PORM1PCT	91637	1
A1R2	RESISTOR,FIXED,FILM 71.15 OHMS,PORM 1PCT, 1/10W, NON-HELIXED SINGER PART NO.556204-015	DC1/10-71.15PORM1PCT	91637	1
A1R3	SAME AS A1R1			
A1R4	RESISTOR,FIXED,FILM, 61.11OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-013	DC1/10-61.11PORM1PCT	91637	1
A1R5	RESISTOR,FIXED,FILM, 247.5OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO.556204-023	DC1/10-247.5PORM1PCT	91637	1
A1R6	SAME AS A1R4			
A1R7	RESISTOR,FIXED,FILM, 53.27OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-012	DC1/10-53.27PORM1PCT	91637	1
A1R8	RESISTOR,FIXED,FILM, 790.0OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO.556204-026	DC1/10-790.0PORM1PCT	91637	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A1R9	SAME AS A1R7			
A1R10	RESISTOR,FIXED,FILM, 51.01OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-010	DC1/10-51.01PORM1PCT	91637	1
A1R11	RESISTOR,FIXED,FILM, 2500 OHMS,PORM 1 PCT, 1/8W,NON-HELIXED SINGER PART NO. 556204-100	DC1/8-2500PORM1PCT	91637	1
A1R12	SAME AS A1R10			
A1R13	RESISTOR,FIXED,FILM, 50.32OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-009	DC1/10-50.32PORM1PCT	91637	1
A1R14	RESISTOR,FIXED,FILM, 7910 OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO.556204-101	DC1/8-7910PORM1PCT	91637	1
A1R15	SAME AS A1R13			
A1R16	RESISTOR,FIXED,FILM, 50.1 OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-008	DC1/10-50.1 PORM1PCT	91637	1
A1R17 AND R18	RESISTOR,FIXED,COMP., 12K OHMS,PORM 5 PCT, 1/8W SINGER PART NO. 556146-763	BB1235	01121	1
A1R19	SAME AS A1R16			
A1R20	RESISTOR,FIXED,FILM, 870.0OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO.556204-027	DC1/10-870.0PORM1PCT	91637	1
A1R21	RESISTOR,FIXED,FILM, 5.77 OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-001	DC1/10-5.77 PORM1PCT	91637	1
A1R22	SAME AS A1R20			
A1R23	RESISTOR,FIXED,FILM, 436.2OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO.556204-025	DC1/10-436.2PORM1PCT	91637	1
A1R24	RESISTOR,FIXED,FILM, 11.61OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-002	DC1/10-11.61PORM1PCT	91637	1
A1R25	SAME AS A1R23			
A1R26	RESISTOR,FIXED,FILM, 292.4OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO.556204-024	DC1/10-292.4PORM1PCT	91637	1
A1R27	RESISTOR,FIXED,FILM, 17.61OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-003	DC1/10-17.61PORM1PCT	91637	1
A1R28	SAME AS A1R26			
A1R29	RESISTOR,FIXED,FILM, 221.0OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO.556204-022	DC1/10-221.0PORM1PCT	91637	1
A1R30	RESISTOR,FIXED,FILM, 23.85OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-004	DC1/10-23.85PORM1PCT	91637	1
A1R31	SAME AS A1R29			
A1R32	RESISTOR,FIXED,FILM, 178.5OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO.556204-021	DC1/10-178.5PORM1PCT	91637	1
A1R33	RESISTOR,FIXED,FILM, 30.4 OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-005	DC1/10-30.4 PORM1PCT	91637	1
A1R34	SAME AS A1R32			
A1R35	RESISTOR,FIXED,FILM, 150.5OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-020	DC1/10-150.5PORM1PCT	91637	1

TABLE 6-2. PARTS LIST

Ref Symbol		Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A1R36		RESISTOR,FIXED,FILM, 37.35OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-006	DC1/10-37.35PORM1PCT	91637	1
A1R37		SAME AS A1R35			
A1R38		RESISTOR,FIXED,FILM, 130.7OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-01	DC1/10-130.7PORM1PCT	91637	1
A1R39		RESISTOR,FIXED,FILM, 44.8 OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-007	DC1/10-44.8 PORM1PCT	91637	1
A1R40		SAME AS A1R38			
A1R41		RESISTOR,FIXED,FILM, 116.1OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-018	DC1/10-116.1PORM1PCT	91637	1
A1R42		RESISTOR,FIXED,FILM, 52.84OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-011	DC1/10-52.84PORM1PCT	91637	1
A1R43		SAME AS A1R41			
A1R44		RESISTOR,FIXED,FILM, 105.0OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-017	DC1/10-105.0PORM1PCT	91637	1
A1R45		RESISTOR,FIXED,FILM, 61.59OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-014	DC1/10-61.59PORM1PCT	91637	1
A1R46		SAME AS A1R44			
A1W4		CABLE ASSY	102-9200-370	16665	1
A1W4P1 P2	AND	SAME AS P7		98291	1
A2		FRONT IF ASSY	103-1584-002	16665	1
A2C1 C2	AND	CAPACITOR,FIXED,FEED-THRU, 1000 PF,PORM 20 PCT,500V SINGER PART NO. 556146-899	2499-003-X5S0-102M	72982	1
A2C6 C8	THRU	SAME AS A2C1			
A2C10 C11	AND	SAME AS A2C1			
A2C13 C23	THRU	SAME AS A2C1			
A2FL1 FL3	THRU	FILTER,FEED-THRU, 5000 PF SINGER PART NO. 556146-774	1270-016	72982	10
A2J1		SAME AS P9			
A2J2 J4	THRU	CONNECTOR, JACK SINGER PART NO. 168-4034-001	51-010-0000	98291	1
A2P1		CONNECTOR,PLUG, 2 TERMINALS	128-1036-010	16665	1
A2P2		CONNECTOR,PLUG, 4 TERMINALS	128-1036-004	16665	1
A2P3		CONNECTOR,PLUG, 2 TERMINALS	128-1036-009	16665	1
A2P4		CONNECTOR,PLUG, 2 TERMINALS	128-1036-008	16665	1
A2P5		CONNECTOR,PLUG, 4 TERMINALS	128-1036-002	16665	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2P6	CONNECTOR,PLUG, 6 TERMINALS	128-1036-003	16665	1
A2P7	CONNECTOR,PLUG, 4 TERMINALS	128-1036-005	16665	1
A2P8	CONNECTOR,PLUG, 3 TERMINALS	128-1037-002	16665	1
A2P9 THRU P11	CONNECTOR, PLUG, PHONO SINGER PART NO. 556147-239	202-19-01-092	71785	1
A2W1	CABLE ASSY	102-9200-415	16665	1
A2W1P1 AND P2	SAME AS A2P9	202-19-01-092	71785	1
A2W2	CABLE ASSY	102-9200-410	16665	1
A2W2P1 AND P2	SAME AS A2P9			
A2W4	CABLE ASSY	102-9200-431	16665	1
A2W4P1 AND P2	SAME AS A2P9			
A2W5 AND W6	CABLE ASSY	102-9200-430	16665	1
A2W5P1 AND P2	SAME AS A2P9			
A2W6P1 AND P2	SAME AS A2P9			
A2W7	CABLE ASSY	102-9200-432	16665	1
A2W7P1 AND P2	SAME AS A2P9			
A2W8	CABLE ASSY	102-9200-416	16665	1
A2W8P1 AND P2	SAME AS A2P9			
A2W9	CABLE ASSY	102-9200-417	16665	1
A2W9P1 AND P2	SAME AS A2P9			
A2A1	MARKER OSCILLATOR ASSY	103-1552-002	16665	1
A2A1CR1 THRU CR4	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556118-041	IN34A	93332	1
A2A1C1 AND C2	SAME AS C1			
A2A1C3	CAPACITOR,FIXED,COMP., 1.5 PF,PORM 5 PCT, 500V SINGER PART NO. 150-4001-1R5J	GA1.5PFPORMKPCT	78488	1
A2A1C4	CAPACITOR,FIXED,DIPPED MICA, 27 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-270EJO	DM15E270JO500WV4CR	72136	1
A2A1C5	CAPACITOR,VARIABLE, 2 TO 8 PF SINGER PART NO. 150-0008-001	538-011A2-8	72982	1
A2A1C6 AND C7	SAME AS C1			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A1C8	CAPACITOR,FIXED,CERAMIC, 0.1 UF,PORM 20 PCT, 25V SINGER PART NO. 556120-162	5C023104X0250B3	56289	1
A2A1C9	CAPACITOR,FIXED,CERAMIC DISC, 0.01 UF,PLUS 60 MINUS 40 PCT,250V SINGER PART NO. 556060-146	DA140-1728	71590	3
A2A1C10	SAME AS A2A1C3			
A2A1C11	CAPACITOR,FIXED,COMP., 1.0 PF,PORM 10 PCT, 500V SINGER PART NO. 150-4001-1R0K	GA1PFPORM10PCT	78488	1
A2A1C12	CAPACITOR,VARIABLE, 7 TO 25 PF SINGER PART NO. 150-0008-004	538-011B7-25	72982	1
A2A1C13	SAME AS C1			
A2A1C14	CAPACITOR,FIXED,DIPPED MICA, 50 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-500EJ0	DM15E500J0500WV4CR	72136	1
A2A1C15	SAME AS A2A1C9			
A2A1C16	CAPACITOR,FIXED,COMP., 2.2 PF,PORM 10 PCT, 500V SINGER PART NO. 150-4001-2R2K	GA2.2PFPORM10PCT	78488	1
A2A1C17	SAME AS A2A1C8			
A2A1C18	CAPACITOR,FIXED,DIPPED MICA, 510PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-511EJ0	DM15E511J0500WV4CR	72136	1
A2A1C19	CAPACITOR,VARIABLE, 9 TO 35 PF SINGER PART NO. 150-0008-008	538-011D9-35	72982	1
A2A1C20	CAPACITOR,FIXED,DIPPED MICA, 10 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-100EJ0	DM15E100J0500WV4CR	72136	1
A2A1C21	CAPACITOR,FIXED,DIPPED MICA, 470PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-471EJ0	DM15E471J0500WV4CR	72136	1
A2A1C22	SAME AS A2A1C8			
A2A1C23	SAME AS C1			
A2A1J1	CONNECTOR, JACK, PHONO SINGER PART NO. 556024-272	1233	83330	1
A2A1L1	INDUCTOR	132-0242-001	16665	1
A2A1L2	INDUCTOR	132-0243-001	16665	1
A2A1L3	INDUCTOR	132-0241-001	16665	1
A2A1L4	INDUCTOR	132-0237-001	16665	1
A2A1L5	INDUCTOR	132-0238-001	16665	1
A2A1L6	INDUCTOR,SHIELDED, 100 UH SINGER PART NO. 556200-010	DINK-100	78526	1
A2A1Q1 THRU Q3	TRANSISTOR SINGER PART NO. 556146-251	2N3563	14936	2
A2A1Q4	TRANSISTOR SINGER PART NO. 556146-254	2N3565	07263	1
A2A1R1	RESISTOR,FIXED,COMP., 100 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-101J	CB1015	01121	5

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A1R2	SAME AS R19			
A2A1R3	SAME AS A2A1R1			
A2A1R4 AND R5	SAME AS R19			
A2A1R6	RESISTOR,FIXED,COMP., 150 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-151J	CB1515	01121	4
A2A1R7	RESISTOR,FIXED,COMP., 39 OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-390J	CB3905	01121	1
A2A1R8	SAME AS A2A1R6			
A2A1R9	RESISTOR,FIXED,COMP., 330 OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-331J	CB3315	01121	2
A2A1R10 AND R11	RESISTOR,FIXED,COMP., 12K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-123J	CB1235	01121	4
A2A1R12	RESISTOR,FIXED,COMP., 68 OHMS,PORM 5 PCT 1/4W SINGER PART NO. 151-1002-680J	CB6805	01121	1
A2A1R13	RESISTOR,FIXED,COMP., 240 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-241J	CB2415	01121	1
A2A1R14 AND R15	RESISTOR,FIXED,COMP., 22K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-223J	CB2235	01121	1
A2A1R16	RESISTOR,FIXED,COMP., 3900 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-392J	CB3925	01121	1
A2A1R17	RESISTOR,FIXED,COMP., 1.8K OHM,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-182J	CB1825	01121	2
A2A1R18 AND R19	SAME AS A2A1R14			
A2A1R20	SAME AS A2A1R16			
A2A1R21	SAME AS A2A1R13			
A2A1T1	TRANSFORMER	132-0235-001	16665	1
A2A1T2	TRANSFORMER,RF	132-0234-001	16665	1
A2A2	MARKER LEVEL ASSY	103-1553-002	16665	1
A2A2CR1 AND CR2	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556146-880	FDH-666	07263	1
A2A2C1 THRU C3	SAME AS C1			
A2A2J1 AND J2.	SAME AS A2A1J1			
A2A2R1	SAME AS R19			
A2A2R2	SAME AS A2A1R1			
A2A2R3	SAME AS R19			
A2A3	160-MHZ WIDEBAND AMPLIFIER ASSY	103-1554-002	16665	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A3C1	CAPACITOR,FIXED,COMP., 6.8 PF,PORM 5 PCT, 500V SINGER PART NO. 150-4001-6R8J	GA6.8PFPORM5PCT	78488	1
A2A3C2	CAPACITOR,VARIABLE, 2.5PF TO 11PF SINGER PART NO. 150-0008-003	538-011B2.5.11	72982	1
A2A3C3	SAME AS C1			
A2A3C4 AND C5	CAPACITOR,FIXED,CERAMIC DISC, 470 PF,PORM 10 PCT,1000V SINGER PART NO. 556146-695	DD471	71590	1
A2A3C6	CAPACITOR,FIXED,DIPPED MICA, 250PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-251EJO	DM15E251JO500WV4CR	72136	1
A2A3C7	SAME AS A2A3C4			
A2A3C8	CAPACITOR,FIXED,DIPPED MICA, 36 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-360EJO	DM15E360JO500WV4CR	72136	1
A2A3C9	SAME AS A2A3C6			
A2A3C10 AND C11	SAME AS A2A3C4			
A2A3C12	SAME AS A2A3C6			
A2A3C13	SAME AS A2A3C4			
A2A3C14	SAME AS C1			
A2A3C15 AND C16	SAME AS A2A3C4			
A2A3C17 AND C18	SAME AS A2A1C5			
A2A3J1 THRU J3	SAME AS A2A1J1			
A2A3L1	INDUCTOR	132-0322-001	16665	1
A2A3L2	INDUCTOR,VARIABLE	132-0312-001	16665	1
A2A3L3	INDUCTOR,VARIABLE	132-0226-001	16665	1
A2A3L4	COIL,RF,0.68 UH SINGER PART NO. 556012-013	CLA-0.68PORM10PCT	75042	1
A2A3L5	CHOKE,RF,1UH SINGER PAWRT NO. 556012-147	2150-04	99800	1
A2A3L6	INDUCTOR	132-0323-001	16665	1
A2A3Q1 THRU Q4	TRANSISTOR SINGER PART NO. 556147-178	S24058	07263	1
A2A3R1 AND R2	RESISTOR,FIXED,COMP., 8.2 OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-8R2J	CB8R25	01121	1
A2A3R3	RESISTOR,FIXED,COMP.,150 OHMS,PORM 5PCT 1/4W SINGER PART NO. 151-1002-151J	CB1525	01121	1
A2A3R4	SAME AS A2A1R17			
A2A3R5	RESISTOR,FIXED,COMP., 680 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-681J	CB6815	01121	1
A2A3R6	RESISTOR,FIXED,COMP., 390 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-391J	CB3915	01121	2

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A3R7	RESISTOR,FIXED,COMP., 360 OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-361J	CB3615	01121	2
A2A3R8	RESISTOR,FIXED,COMP., 18 OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-180J	CB1805	01121	1
A2A3R9	RESISTOR,FIXED,COMP., 1.5K OHM,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-152J	CB1525	01121	4
A2A3R10	RESISTOR,FIXED,COMP., 300 OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-301J	CB3015	01121	1
A2A3R11	SAME AS A2A3R6			
A2A3R12	RESISTOR,FIXED,COMP.,91 OHMS PORM 5PCT 1/4W SINGER PART NO. 151-1002-910J	CB9105	01121	1
A2A3R13	SAME AS A2A3R7			
A2A3R14	SAME AS A2A3R8			
A2A3R15	SAME AS A2A1R6			
A2A3R16	RESISTOR,FIXED,COMP.,390 OHMS PORM 5PCT 1/4W SINGER PART NO. 151-1002-391J	CB3915	01121	1
A2A3R17	SAME AS A2A3R7			
A2A3R18	SAME AS A2A3R12			
A2A3R19	SAME AS A2A3R8			
A2A3R20	SAME AS A2A1R6			
A2A3R21 AND R22	SAME AS A2A3R7			
A2A3R23	SAME AS A2A3R12			
A2A3R24	RESISTOR,FIXED,COMP., 470 OHMS PORM 5PCT 1/4W SINGER PART NO. 151-1002-471J	CB4715	01121	1
A2A4	HIGH-PASS FILTER ASSY	103-1555-002	16665	1
A2A4C1	SAME AS A2A1C20			
A2A4C2	CAPACITOR,FIXED,DIPPED MICA, 20 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-200EJ0	DM15E200J0500WV4CR	72136	1
A2A4C3	CAPACITOR,FIXED,DIPPED MICA, 39 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-390EJ0	DM15E390J0500WV4CR	72136	1
A2A4C4	CAPACITOR,VARIABLE, 5.5 TO 18 PF,350V SINGER PART NO. 151-0004-002	538-006CP092R	72982	1
A2A4C5	SAME AS A2A4C2			
A2A4J1 AND J2	CONNECTOR, JACK, PHONO, RT ANGLE SINGER PART NO. 556147-238	571	91833	1
A2A4L1 AND L2	INDUCTOR	132-0245-001	16665	1
A2A4R1	RESISTOR,FIXED,COMP., 560 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-561J	CB5615	01121	3

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A4R2	RESISTOR,FIXED,COMP., 30 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-300J	CB3005	01121	2
A2A4R3	SAME AS A2A4R1			
A2A4R4	SAME AS A2A4R2			
A2A4R5	RESISTOR,FIXED,COMP., 120 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-121J	CB1215	01121	1
A2A4R6	SAME AS A2A4R2			
A2A5	LOW-PASS FILTER ASSY	103-1556-002	16665	1
A2A5C1	CAPACITOR,FIXED,COMP., 4.7PF,PORM 5 PCT,500V SINGER PART NO. 150-4001-4R7J	GA4.7PFPORM5PCT	78488	1
A2A5C2 AND C3	CAPACITOR,VARIABLE, 0.8 TO 4.5PF SINGER PART NO. 150-0010-001	V1270	18736	
A2A5C4	CAPACITOR,FIXED,COMP., 1.8 PF,PORM 5 PCT, 500V SINGER PART NO. 150-4001-1R8J	GA1.8PFPORM5PCT	78488	1
A2A5C5	SAME AS A2A5C2			
A2A5J1 AND J2	SAME AS A2A4J1			
A2A5L1	INDUCTOR	132-0246-001	16665	1
A2A5L2	INDUCTOR	132-0247-001	16665	1
A2A5L3	INDUCTOR	132-0248-001	16665	1
A2A5L4	INDUCTOR	132-0249-001	16665	1
A2A5L5	SAME AS A2A5L3			
A2A5L6	SAME AS A2A5L4			
A2A5L7	SAME AS A2A5L1			
A2A6	LOW-PASS FILTER ASSY	103-1557-002	16665	1
A2A6C1	SAME AS A2A1C16			
A2A6C2	SAME AS A2A5C2			
A2A6C3	SAME AS A2A1C16			
A2A6C4	SAME AS A2A5C2			
A2A6C5	CAPACITOR,FIXED,COMP., 10 PF,PORM 5 PCT,500V SINGER PART NO. 150-4001-100J	GA10PFPORM5PCT	78488	1
A2A6J1 AND J2	SAME AS A2A4J1			
A2A6L1	INDUCTOR	132-0252-001	16665	1
A2A6L2 AND L3	SAME AS A2A5L1			
A2A6L4	SAME AS A2A5L4			
A2A6L5	SAME AS A2A5L1			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A6R1	SAME AS A2A3R9			
A2A6R2	RESISTOR,FIXED,COMP., 10 OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-100J	CB1005	01121	1
A2A6R3	SAME AS A2A3R9			
A2A6R4	SAME AS A2A4R1			
A2A6R5	SAME AS A2A4R2			
A2A6R6	SAME AS A2A4R1			
A2A7	WIDEBAND/NARROWBAND SWEPT OSCILLATOR ASSY	103-1558-002	16665	1
A2A7CR1 THRU CR4	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556146-687	1N82AG	81349	1
A2A7CR5	SAME AS A2A2CR1			
A2A7CR6	SEMICONDUCTOR DEVICE.DIODE SINGER PART NO. 556147-023	1N942A	81349	1
A2A7C1	CAPACITOR,FIXED,CERAMIC, 0.47 UF,PORM 20 PCT 25V SINGER PART NO.556120-160	5C11	56289	3
A2A7C2 THRU C4	CAPACITOR,FIXED,ELECTROLYTIC, 10 UF,PLUS 75 MINUS 10 PCT,15V SINGER PART NO. 150-5001-100DS	TE-1155	56289	1
A2A7C5	CAPACITOR,FIXED,FEED-THRU, 1000 PF,PORM 20 PCT,300V SINGER PART NO. 556147-112	FW5N/1000PF,W/M-6447	01121	1
A2A7C6	CAPACITOR,FIXED,COMP. 0.82PF PORM 10PCT 500V SINGER PART NO. 150-4001-R82K	GA0.82PFPORM10PCT	78488	1
A2A7C7	CAPACITOR,FIXED,COMP., 1 PF,PORM 5 PCT,500V SINGER PART NO. 150-4001-1R0J	GA1.0PFPORM5PCT	78488	1
A2A7C8	SAME AS A2A1C5			
A2A7C9 AND C10	SAME AS C1			
A2A7C11	SAME AS A2A1C19			
A2A7C12	SAME AS A2A3C8			
A2A7C13	CAPACITOR,FIXED,DIPPED MICA, 30 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-300EJ0	DM15E300J0500WV4CR	72136	1
A2A7C14	SAME AS C1			
A2A7C15	SINGER PART NO. 150-4001-2R4J	GA2.4 PF,PORM 5 PCT	78488	
A2A7C16	CAPACITOR,FIXED,DISC 200PF PORM 10PCT 1KV SINGER PART NO. 556146-696	DD-201	71590	1
A2A7C17	SAME AS C1			
A2A7C18	SAME AS A2A7C2			
A2A7C19	CAPACITOR,FIXED,DIPPED MICA, 15 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-150EJ0	DM15E150J0500WV4CR	72136	1
A2A7C20	CAPACITOR,VARIABLE, 47 PF,PORM 20 PCT,80V SINGER PART NO. 556146-095	VC347	19373	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A7C21	CAPACITOR,FIXED,COMP., 7.5 PF,PORM 5 PCT, 500V SINGER PART NO. 150-4001-7R5J	GA7.5PFPORM5PCT	78488	1
A2A7C22 AND C23	SAME AS C1			
A2A7C24	CAPACITOR FIXED, 0.01UF SINGER PART NO. 556060-146	DA140-172B	71590	1
A2A7C25	CAPACITOR,FIXED,ELECTROLYTIC, 10 UF,PLUS 75 MINUS 10 PCT,100V SINGER PART NO. 150-5001-100GS	TE-1407	56289	
A2A7C26 AND C27	SAME AS C1			
A2A7C28	SAME AS A2A7C2			
A2A7J1 AND J2	SAME AS A2A1J1			
A2A7L1 THRU L3	CHOKE,SHIELDED, 5 MH SINGER PART NO. 556147-022	670-5	04213	1
A2A7L4	INDUCTOR,CURRENT CONTROL	132-0221-001	16665	1
A2A7L5	COIL	132-0239-001	16665	1
A2A7L6	SAME AS A2A7L1			
A2A7Q1	TRANSISTOR SINGER PART NO. 556146-676	2N3642	81349	1
A2A7Q2	TRANSISTOR	132-0317-001	16665	1
A2A7Q3	SAME AS A2A1Q1			
A2A7Q4	TRANSISTOR SINGER PART NO. 556146-680	2N3932	81349	1
A2A7Q5	SAME AS A2A1Q1			
A2A7Q6	TRANSISTOR SINGER PART NO. 556146-682	SE-7010	07263	1
A2A7Q7	TRANSISTOR SINGER PART NO. 556146-254	2N3565	07263	1
A2A7RV1	VARISTOR, 6V TO 11V SINGER PART NO. 556052-059	114W3	83186	1
A2A7RV2	VARISTOR, 10V,PORM 30 PCT AT 5 MA SINGER PART NO. 556146-738	063L9	83186	1
A2A7R1	SAME AS R35			
A2A7R2	SAME AS R32			
A2A7R3	RESISTOR,FIXED,COMP., 150K OHM,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-154J	CB1545	01121	1
A2A7R4	RESISTOR,FIXED,COMP., 2K OHM,PORM 5 PCT,1/4W SINGER PART NO. 151-1002-202J	CB2025	01121	1
A2A7R5	SAME AS A2A1R1			
A2A7R6	SAME AS R22			
A2A7R7	RESISTOR,FIXED,COMP., 68K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-683J	CB6835	01121	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A7R8	RESISTOR,VARIABLE, 2.8 KOHMS,1/4W SINGER PART NO. 556197-194	VR025-2801	99517	1
A2A7R9	RESISTOR,VARIABLE, 250 OHMS,W.W. SINGER PART NO. 556146-764	115/250OHMS	11236	1
A2A7R10	RESISTOR,FIXED,COMP., 10 OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-100J	EB1005	01121	1
A2A7R11	SAME AS A2A1R1			
A2A7R12	SAME AS A2A1R17			
A2A7R13	RESISTOR,FIXED,COMP., 430 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-431J	CB4315	01121	1
A2A7R14	RESISTOR,VARIABLE, 500 OHMS,PORM 20 PCT,1/4W SINGER PART NO. 151-0021-002	UHT201-2/50020,PCT	11236	1
A2A7R15 AND R16	RESISTOR,FIXED,COMP., 18K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-183J	CB1835	01121	4
A2A7R17	SAME AS A2A4R1			
A2A7R18	SAME AS R19			
A2A7R19	RESISTOR,FIXED,COMP. 2.4K OHMS,PORM 5PCT 1/4W SINGER PART NO. 150-1002-242J	CB2425	01121	1
A2A7R20	RESISTOR,FIXED,COMP., 100K OHM,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-104J	CB1045	01121	1
A2A7R21	SAME AS R50			
A2A7R22	RESISTOR,FIXED,COMP., 10K OHMS ,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-103J	EB1035	01121	1
A2A7R23	SAME AS R35			
A2A7R24	SAME AS R19			
A2A7R25	RESISTOR,VARIABLE, 10K OHMS,PORM 20 PCT,1/4W SINGER PART NO. 151-0021-006	UHT201-2/10K,20PCT	11236	1
A2A7R26	RESISTOR,FIXED,COMP., 91K OHMS ,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-913J	EB9135	01121	1
A2A7R27	SAME AS R32			
A2A7R28	SAME AS A2A1R17			
A2A7R29	RESISTOR,FIXED,COMP.,3.6K OHMS PORM 5PCT 1/4W SINGER PART NO. 151-1002-362J	CB3625	01121	1
A2A7R30	SAME AS R32			
A2A7R31	RESISTOR,FIXED,COMP., 12K OHMS ,PORM 5 PCT, 1W SINGER PART NO. 151-1004-123J	GB1235	01121	1
A2A7R32	RESISTOR,FIXED,COMP., 15 OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-150J	CB1505	01121	1
A2A7T1	TRANSFORMER	132-0267-001	16665	1
A2A7T2	TORIOD	132-0261-001	16665	1
A2A7T3	TRANSFORMER,VARIABLE	132-0227-001	16665	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A8	60-MHZ IF AMPLIFIER ASSY	103-1559-002	16665	1
A2A8C1	CAPACITOR,FIXED,DIPPED MICA, 100PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-101EJ0	DM15E101H0500WV4CR	72136	1
A2A8C2	CAPACITOR,FIXED,DIPPED MICA 56 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-560EJ0	DM15E560J0500WV4CR	72136	1
A2A8C3 AND C4	SAME AS C1			
A2A8C5	SAME AS A2A8C1			
A2A8C6	CAPACITOR,FIXED,DIPPED MICA, 22 PF, PORM 5 PCT,500V SINGER PART NO. 150-2002-220EJ0	DM15E220J0500WV4CR	72136	1
A2A8C7 THRU C15	SAME AS C1			
A2A8C16	CAPACITOR,FIXED,DIPPED MICA, 33 PF, PORM 5 PCT, 500V SINGER PART NO. 150-2002-330EJ0	DM15E330J0500WV4CR	72136	1
A2A8C17	CAPACITOR,FIXED,DIPPED MICA, 82 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-820EJ0	DM15E820J0500WV4CR	72136	1
A2A8C18 AND C19	SAME AS C1			
A2A8C20	SAME AS A2A8C2			
A2A8C21	SAME AS A2A8C1			
A2A8J1 THRU J3	SAME AS A2A1J1			
A2A8L1	INDUCTOR,VARIABLE	132-0228-001	16665	1
A2A8L2	INDUCTOR,SHIELDED, 5.6 UH SINGER PART NO. 556200-006	DINK-5.6	78526	2
A2A8L3	COIL	132-0240-001	16665	1
A2A8L4	INDUCTOR,VARIABLE	132-0229-001	16665	1
A2A8L5	SAME AS A2A8L2			
A2A8L6	SAME AS A2A8L4			
A2A8L7	SAME AS A2A8L2			
A2A8L8	SAME AS A2A8L1			
A2A8Q1 AND Q2	SAME AS A2A1Q1			
A2A8Q3	TRANSISTOR SINGER PART NO. 556146-683	SE-5001	07263	1
A2A8Q4	SAME AS A2A1Q1			
A2A8R1	SAME AS A2A3R10			
A2A8R2	SAME AS A2A3R8			
A2A8R3	SAME AS A2A3R10			
A2A8R4	SAME AS R19			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A8R5 THRU	SAME AS R13			
A2A8R8	SAME AS A2A1R1			
A2A8R9	SAME AS R13			
A2A8R10	SAME AS A2A1R1			
A2A8R11	RESISTOR,FIXED,COMP., 75 OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-750J	CB7505	01121	1
A2A8R12	SAME AS A2A1R1			
A2A8R13	SAME AS R19			
A2A8R14	RESISTOR,FIXED,COMP., 510 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-511J	CB5105	01121	1
A2A8R15	SAME AS A2A4R1			
A2A8R16	RESISTOR,FIXED,COMP., 910 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-911J	CB9115	01121	1
A2A8R17	SAME AS A2A3R5			
A2A8R18 AND R19	SAME AS R13			
A2A8R20	SAME AS R19			
A2A8R21	RESISTOR,VARIABLE, 100 OHMS,PORM 20 PCT,1/4W SINGER PART NO. 151-0021-007	UHT201-2/100,20PCT	11236	1
A2A9	60/6.5-MHZ CONVERTER ASSY	103-1560-002	16665	1
A2A9C1 AND C2	SAME AS C1			
A2A9C3	CAPACITOR,FIXED,DIPPED MICA, 270PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-271EJ0	DM15E271J0500WV4CR	72136	1
A2A9C4	SAME AS A2A1C20			
A2A9C5	SAME AS A2A7C13			
A2A9C6	CAPACITOR,FIXED,DIPPED MICA, 62 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-620EJ0	DM15E620J0500WV4CR	72136	1
A2A9C7	CAPACITOR,FIXED,DIPPED MICA, 75 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-750EJ0	DM15E750J0500WV4CR	72136	1
A2A9C8	CAPACITOR,FIXED,DIPPED MICA, 68 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-680EJ0	DM15E680J0500WV4CR	72136	1
A2A9C9 AND C10	SAME AS A2A1C9			
A2A9C11	CAPACITOR,FIXED,DIPPED MICA 200PF PORM5PCT SINGER PART NO. 150-2002-201EJ0	DM15F201J0500WV4CR	72136	
A2A9C12	SAME AS A2A1C9			
A2A9C13	SAME AS C1			
A2A9C14	SAME AS A2A1C14			
A2A9C15	SAME AS A2A1C16			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A9C16	SAME AS A2A1C14			
A2A9J1 AND J2	SAME AS A2A1J1			
A2A9L1	INDUCTOR,VARIABLE	132-0230-001	16665	1
A2A9Q1 AND Q2	SAME AS A2A1Q1			
A2A9R1	SAME AS A2A1R1			
A2A9R2 AND R3	SAME AS R13			
A2A9R4	SAME AS R19			
A2A9R5	SAME AS R47			
A2A9R6 AND R7	SAME AS R13			
A2A9R8	SAME AS A2A3R8			
A2A9R9	SAME AS R19			
A2A9R10	SAME AS A2A1R6			
A2A9R11	SAME AS A2A1R7			
A2A9R12	SAME AS A2A1R6			
A2A9T1	TRANSFORMER,VARIABLE	132-0232-001	16665	1
A2A9T2 AND T3	TRANSFORMER,VARIABLE	132-0231-001	16665	1
A2A9Y1	CRYSTAL,53.5 MHZ SINGER PART NO. 556146-692	CR55/U 53.5 MHZ	81349	1
A3	BACK IF ASSY	103-1585-002	16665	1
A3C1 THRU C14	CAPACITOR,FIXED,FEED-THRU, 0.02 UF,PLUS 80, MINUS 20 PCT, SINGER PART NO. 556202-001	533C14A	56289	2
A3C15 THRU C24	SAME AS A2A7C1			
A3C25 AND C26	SAME AS A2C1			
A3J1	CONNECTOR,PLUG SINGER PART NO. 556146-752	SM14-20PGD	95238	1
A3J2 THRU A3J5	SAME AS A2J2			
A3P1	CONNECTOR,PLUG, 4 TERMINALS	128-1037-001	16665	1
A3P2	CONNECTOR,PLUG, 2 TERMINALS	128-1036-011	16665	1
A3P3	CONNECTOR,PLUG, 7 TERMINALS	128-1036-001	16665	1
A3P4	CONNECTOR,PLUG, 3 TERMINALS	128-1036-007	16665	1
A3P5	CONNECTOR,PLUG, 3 TERMINALS	128-1036-006	16665	1
A3P6	SAME AS A2P4		16665	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3P7 THRU P10	SAME AS A2P9			
A3W2	SAME AS A2W2			
A3W2P1 AND P2	SAME AS A2P9			
A3W3	CABLE ASSY	102-9200-411	16665	1
A3W3P1 AND P2	SAME AS A2P9			
A3W4	CABLE ASSY	102-9200-412	16665	1
A3W4P1 AND P2	SAME AS A2P9			
A3W5	CABLE ASSY	102-9200-413	16665	1
A3W5P1 AND P2	SAME AS A2P9			
A3W7	CABLE ASSY	102-9200-414	16665	1
A3W7P1 AND P2	SAME AS A2P9			
A3A1	6.5-MHZ WIDEBAND FILTER ASSY	103-1561-002	16665	1
A3A1CR1 THRU CR4	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556118-046	IN251	93332	2
A3A1C1 AND C2	SAME AS A2A1C9			
A3A1C3 AND C4	SAME AS A2A7C1			
A3A1C5 THRU C7	SAME AS A2A1C9			
A3A1C8	SAME AS A2A8C2			
A3A1C9	SAME AS A2A1C19			
A3A1C10 AND C11	SAME AS A2A1C9			
A3A1C12 AND C13	SAME AS A2A7C1			
A3A1J1 THRU J3	SAME AS A2A1J1			
A3A1L1	SAME AS A2A8L2			
A3A1L2	INDUCTOR,SHIELDED, 220 UH,PORM 5 PCT SINGER PART NO. 556200-011	D1NK-220	78526	1
A3A1Q1	SAME AS A2A1Q1			
A3A1R1	SAME AS R49			
A3A1R2	SAME AS A2A4R2			
A3A1R3	SAME AS R49			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3A1R4	SAME AS A2A3R9			
A3A1R5	SAME AS R19			
A3A1R6	SAME AS A2A3R9			
A3A1R7	SAME AS R19			
A3A1R8	SAME AS R50			
A3A1R9	SAME AS R22			
A3A1R10	RESISTOR,FIXED,COMP., 6800 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-682J	CB6825	01121	1
A3A1R11	SAME AS A2A8R21			
A3A1R12	SAME AS R13			
A3A2	6.5-MHZ NARROWBAND FILTER ASSY	103-1562-002	16665	1
A3A2C1	SAME AS A2A1C9			
A3A2C2	CAPACITOR FIXED 0.1UF 25V SINGER PART NO. 556120-162	5C023104X0250B3	56289	1
A3A2C3	CAPACITOR,VARIABLE 7 TO 45 PF SINGER PART NO. 556122-090	503-041E2P033R	72982	1
A3A2C4	CAPACITOR,FIXED,DIPPED MICA, 180PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-181EJ0	DM15E181J0500WV4CR	72136	1
A3A2C5	SAME AS A3A2C3			
A3A2C6	SAME AS A3A2C4			
A3A2C7	SAME AS A3A2C3			
A3A2C8	SAME AS A3A2C4			
A3A2C9	SAME AS A3A2C3			
A3A2C10	SAME AS A3A2C4			
A3A2C11	SAME AS A2A3C3			
A3A2C12	SAME AS A3A2C4			
A3A2C13	SAME AS A3A2C3			
A3A2C14	SAME AS A3A2C4			
A3A2C15	SAME AS A3A2C3			
A3A2C16	SAME AS A3A2C4			
A3A2C17	SAME AS A3A2C3			
A3A2C18	SAME AS A3A2C4			
A3A2C19 AND C20	SAME AS A2A1C9			
A3A2C21 THRU C24	SAME AS A3A7C1			
A3A2J1 AND J2	SAME AS A2A1J1			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3A2L1	INDUCTOR,VARIABLE	132-0233-001	16665	1
A3A2L2	SAME AS A2A1L6			
A3A2L3	SAME AS A3A2L1			
A3A2L4	SAME AS A2A1L6			
A3A2L5	SAME AS A3A2L1			
A3A2L6	SAME AS A2A1L6			
A3A2L7	SAME AS A3A2L1			
A3A2L8	SAME AS A2A1L6			
A3A2L9	SAME AS A3A2L1			
A3A2L10	SAME AS A2A1L6			
A3A2L11	SAME AS A3A2L1			
A3A2L12	SAME AS A2A1L6			
A3A2L13	SAME AS A3A2L1			
A3A2L14	SAME AS A2A1L6			
A3A2L15	SAME AS A3A2L1			
A3A2L16 AND L17	SAME AS A3A1L2			
A3A2Q1 AND Q2	TRANSISTOR SINGER PART NO. 556146-677	2N3694	81349	1
A3A2R1	SAME AS R50			
A3A2R2 AND R3	RESISTOR,FIXED,COMP., 6200 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-622J	CB6225	01121	
A3A2R4	SAME AS R50			
A3A2R5	SAME AS A2A1R17			
A3A2R6	SAME AS R22			
A3A2R7	SAME AS A2A8R14			
A3A2R8 AND R9	SAME AS R28			
A3A2R10	SAME AS A2A1R17			
A3A3	6.5-MHZ VARIABLE BANDWIDTH AMPLIFIER ASSY	103-1563-002	16665	1
A3A3CR1 THRU CR4	SAME AS A3A1CR1			
A3A3C1 THRU C4	SAME AS A2A1C8			
A3A3C5	SAME AS A2A1C19			
A3A3C6 THRU C10	SAME AS A2A1C8			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3A3C11	SAME AS A2A1C19			
A3A3C12	SAME AS A3A7C1			
A3A3C13	CAPACITOR,VARIABLE, 2.5 TO 11 PF SINGER PART NO. 150-0008-003	538-011B2.2-11	72982	1
A3A3C15 AND C16	SAME AS A2A1C8			
A3A3C17	SAME AS A2A1C9			
A3A3C18	SAME AS A2A1C8			
A3A3C19	SAME AS A2A7C1			
A3A3C20 AND C21	SAME AS A2A1C8			
A3A3C22	SAME AS A2A8C17			
A3A3C23	SAME AS A2A1C19			
A3A3C25	SAME AS A2A1C8			
A3A3C26	SAME AS A3A3C13			
A3A3C27	SAME AS A3A3C11			
A3A3C28	SAME AS A2A1C8			
A3A3C30 AND C31	SAME AS A2A1C8			
A3A3C34 THRU C37	SAME AS A2A7C1			
A3A3C38 THRU C41	SAME AS A2A1C8			
A3A3C42 AND C43	SAME AS A2A7C1			
A3A3C44	CAPACITOR,FIXED,CERAMIC, 12 PF,PORM 10 PCT SINGER PART NO. 556147-249	301N75012PFPORM10PCT	72982	1
A3A3C45	SAME AS A2A1C9			
A3A3C46	SAME AS A3A3C44			
A3A3C47	SAME AS A2A1C9			
A3A3J1 THRU J3	SAME AS A2A1J1			
A3A3L1	INDUCTOR,SHIELDED, 10 UH SINGER PART NO. 556200-008	DINK-10	78526	1
A3A3L2 THRU L4	SAME AS A2A1L6			
A3A3L5	INDUCTOR,VARIABLE	132-0324-001	16665	1
A3A3L6	SAME AS A2A1L6			
A3A3L8	SAME AS A2A1L6			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3A3L10	INDICTOR,SHIELDED, 4.7 UH SINGER PART NO. 556200-005	DINK-4.7	78526	1
A3A3L12	SAME AS A3A3L5			
A3A3L14 AND L15	SAME AS A2A1L6			
A3A3L16 AND L17	SAME AS A3A1L2			
A3A3Q1	SAME AS A3A2Q1			
A3A3Q2 AND Q3	TRANSISTOR SINGER PART NO. 556146-672	2N3015	81349	1
A3A3Q4 THRU Q7	SAME AS A3A2Q1			
A3A3Q8	SAME AS A2A7Q1			
A3A3R1	SAME AS A2A1R1			
A3A3R2 AND R3	SAME AS R28			
A3A3R4	SAME AS A2A1R12			
A3A3R5	RESISTOR,FIXED,COMP., 1000 OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-102J	EB1025	01121	1
A3A3R6	SAME AS R19			
A3A3R7	SAME AS A2A1R1			
A3A3R8 AND R9	RESISTOR,FIXED,COMP., 2400 OHM,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-242J	CB2425	01121	3
A3A3R10	SAME AS A2A3R9			
A3A3R11	SAME AS R19			
A3A3R12	SAME AS A2A1R1			
A3A3R13	RESISTOR,FIXED,COMP., 3.9K OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-392J	EB392	01121	1
A3A3R14	SAME AS R19			
A3A3R15	RESISTOR,FIXED,COMP., 180 OHMS,PORM 5 PCT,1W SINGER PART NO. 151-1004-181J	GB1815	01121	1
A3A3R16	RESISTOR,FIXED,COMP., 270 OHMS,PORM 5 PCT,1W SINGER PART NO. 151-1004-271J	GB2715	01121	1
A3A3R17	RESISTOR,PHOTO-CONTROLLED SINGER PART NO. 556146-747	CK1121	49956	1
A3A3R18 AND R19	RESISTOR,FIXED,COMP., 2.2K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-222J	CB2225	01121	1
A3A3R20	SAME AS R13			
A3A3R21	SAME AS R19			
A3A3R22	RESISTOR,FIXED,COMP., 11K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-113J	CB1135	01121	2

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3A3R23	SAME AS A2A1R10			
A3A3R24	RESISTOR,FIXED,COMP., 82 OHMS,PORM 5 PCT 1/4W SINGER PART NO. 151-1002-820J	CB8205	01121	1
A3A3R25	RESISTOR,VARIABLE, 250 OHMS,PORM 20 PCT,1/4W SINGER PART NO. 151-0021-001	UHT201-2/250,20PCT	11236	1
A3A3R26	SAME AS R13			
A3A3R27	SAME AS R19			
A3A3R28	SAME AS A2A1R1			
A3A3R29	RESITOR FIXED,COMP.,270 OHMS PORM 5PCT 1/4W SINGER PART NO. 151-1002-271J	CB2715	01121	1
A3A3R30	SAME AS A2A3R5			
A3A3R31	SAME AS R49			
A3A3R32	RESISTOR,FIXED,COMP., 1200 OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-122J	EB1225	01121	1
A3A3R33	SAME AS A3A3R17			
A3A3R34	SAME AS R19			
A3A3R35	SAME AS R47			
A3A3R36	SAME AS R19			
A3A3R37	SAME AS A3A3R8			
A3A3R38	RESISTOR,FIXED,COMP., 1.2K OHM,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-122J	CB1225	01121	3
A3A3R39	SAME AS A3A3R8			
A3A3R40	SAME AS A3A3R38			
A3A3R41	SAME AS R19			
A3A3R42	SAME AS A3A3R18			
A3A3R43	SAME AS A2A7R20			
A3A3R44	SAME AS A2A7R3			
A3A3Y1	CRYSTAL, 6.5 MHZ	134-0033-001	16665	1
A3A3Y2	CRYSTAL, 6.5 MHZ	134-0033-002	16665	1
A3A4	LOG AMPLIFIER ASSY	103-1564-002	16665	1
A3A4CR1 THRU CR6	SAME AS A3A1CR1			
A3A4C1	SAME AS A2A1C8			
A3A4C3	CAPACITOR,FIXED,DIPPED MICA,1000PF,PORM 5 PCT,500V SINGER PART NO. 150-2003-102EJ0	DM19E102J0500WV4CR	72136	1
A3A4C4	SAME AS A2A1C8			
A3A4C5	SAME AS A2A9C7			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3A4C6	SAME AS A2A1C19			
A3A4C7	CAPACITOR,FIXED,DIPPED MICA, 12 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-120EJ0	DM15E120J0500WV4CR	72136	1
A3A4C8	SAME AS A2A8C16			
A3A4C9	SAME AS A2A1C9			
A3A4C10	SAME AS A3A4C3			
A3A4C11	SAME AS A2A1C8			
A3A4C12	SAME AS A2A1C19			
A3A4C13	CAPACITOR,FIXED,DIPPED MICA, 51 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-510EJC	DM15E510J0500WV4CR	72136	
A3A4C14	SAME AS A2A8C16			
A3A4C15	CAPACITOR,FIXED,DIPPED MICA, 24 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-240EJ0	DM15E240J0500WV4CR	72136	1
A3A4C16	SAME AS A2A1C19			
A3A4C17	SAME AS A3A4C3			
A3A4C18	SAME AS A2A1C8			
A3A4C19	SAME AS A2A1C9			
A3A4C20	SAME AS A3A4C13			
A3A4C21	SAME AS A2A8C16			
A3A4C22	SAME AS A3A4C15			
A3A4C23	SAME AS A2A1C9			
A3A4C24	SAME AS A3A4C3			
A3A4C25	SAME AS A2A1C8			
A3A4C26	SAME AS A2A1C19			
A3A4C27	SAME AS A2A4C2			
A3A4C28	SAME AS A2A7C1			
A3A4C29	SAME AS A2A1C21			
A3A4C30	SAME AS A2A8C16			
A3A4C31	SAME AS A3A4C15			
A3A4C32	SAME AS A2A1C9			
A3A4C33	SAME AS A3A4C3			
A3A4C34	SAME AS A2A1C8			
A3A4C35	SAME AS A2A9C7			
A3A4C36	SAME AS A2A1C19			
A3A4C37	SAME AS A2A8C16			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3A4C38	SAME AS A3A4C15			
A3A4C39	SAME AS A2A1C9			
A3A4C40	SAME AS A3A4C3			
A3A4C41	SAME AS A2A1C8			
A3A4C42	SAME AS A2A7C1			
A3A4C43	SAME AS A3A4C13			
A3A4C44	SAME AS A2A1C19			
A3A4C45	SAME AS A2A8C16			
A3A4C46	SAME AS A3A4C15			
A3A4C47	SAME AS A3A4C7			
A3A4C48 THRU C50	SAME AS A2A7C1			
A3A4J1 THRU J3	SAME AS A2A1J1			
A3A4L1	SAME AS A2A8L2			
A3A4L2	SAME AS A2A1L6			
A3A4L3	SAME AS A2A8L2			
A3A4L4	INDUCTOR,SHIELDED, 27 UH SINGER PART NO. 556200-009	DINK-27	78526	2
A3A4L5	SAME AS A2A1L6			
A3A4L6	SAME AS A2A8L2			
A3A4L7	SAME AS A3A4L4			
A3A4L8	SAME AS A2A1L6			
A3A4L9	SAME AS A2A8L2			
A3A4L10	SAME AS A3A4L4			
A3A4L11	SAME AS A2A1L6			
A3A4L12	SAME AS A2A8L2			
A3A4L13	SAME AS A3A4L4			
A3A4L14	SAME AS A2A1L6			
A3A4L15	SAME AS A2A8L2			
A3A4L16	SAME AS A3A4L4			
A3A4L17	SAME AS A3A1L2			
A3A4L18	SAME AS A3A4L4			
A3A4L19 AND L20	SAME AS A3A1L2			
A3A4Q1	TRANSISTOR SINGER PART NO. 556146-681	SE-3002	07263	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3A4Q2 AND Q3	TRANSISTOR SINGER PART NO. 556146-375	2N3646	82389	2
A3A4Q4	SAME AS A3A2Q1			
A3A4Q5 THRU Q7	SAME AS A3A4Q2			
A3A4Q8	TRANSISTOR SINGER PART NO. 556146-674	2N3568	81349	1
A3A4Q9	TRANSISTOR SINGER PART NO. 556146-255	2N3638	07263	2
A3A4R1	SAME AS A2A1R1			
A3A4R2	SAME AS R22			
A3A4R3	RESISTOR,FIXED,COMP., 7500 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-752J	CB7525	01121	2
A3A4R4	SAME AS R50			
A3A4R5	SAME AS A2A4R1			
A3A4R6	SAME AS A2A1R9			
A3A4R7	SAME AS R19			
A3A4R8	SAME AS R28			
A3A4R9	SAME AS A2A3R6			
A3A4R10	SAME AS R22			
A3A4R11	SAME AS A3A4R3			
A3A4R12	RESISTOR,FIXED,COMP., 33 OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-330J	CB3305	01121	1
A3A4R13	SAME AS A2A4R1			
A3A4R14	SAME AS A2A1R9			
A3A4R15	SAME AS R28			
A3A4R16	SAME AS A2A3R6			
A3A4R17	SAME AS R22			
A3A4R18	SAME AS A3A4R3			
A3A4R19	SAME AS A3A4R12			
A3A4R20	SAME AS A2A4R1			
A3A4R21	SAME AS A2A1R9			
A3A4R22	SAME AS R28			
A3A4R23	SAME AS A2A3R6			
A3A4R24	SAME AS R22			
A3A4R25	SAME AS A3A4R3			
A3A4R26	SAME AS A3A4R12			
A3A4R27	SAME AS A2A4R1			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3A4R28	SAME AS A2A1R9			
A3A4R29	SAME AS R28			
A3A4R30 AND R31	SAME AS A2A7R20			
A3A4R32	SAME AS A2A1R1			
A3A4R33	SAME AS R19			
A3A4R34	SAME AS A2A3R6			
A3A4R35	SAME AS R22			
A3A4R36	SAME AS A3A4R3			
A3A4R37	SAME AS A3A4R12			
A3A4R38	SAME AS A2A4R1			
A3A4R39	SAME AS A2A1R9			
A3A4R40	SAME AS R28			
A3A4R41	SAME AS A2A3R6			
A3A4R42	SAME AS A3A4R3			
A3A4R43	SAME AS R22			
A3A4R44	SAME AS A2A8R21			
A3A4R45	SAME AS A2A4R1			
A3A4R46	SAME AS A2A1R9			
A3A4R47	SAME AS R28			
A3A4R48	RESISTOR,VARIABLE, 1000 OHMS,PORM 20 PCT, 1/4W SINGER PART NO. 151-0021-003	UHT201-2/1K,20PCT	11236	1
A3A4R49	SAME AS A2A1R10			
A3A4R50	SAME AS A2A4R5			
A3A4R51	SAME AS A2A1R10			
A3A4R52	SAME AS A2A1R6			
A3A5	LIN/POWER AMPLIFIER ASSY	103-1565-002	16665	1
A3A5CR1	SAME AS A2A2CR1			
A3A5CR2	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556118-105	IN749	81483	1
A3A5C1	SAME AS A2A1C21			
A3A5C2	SAME AS A2A1C19			
A3A5C3	SAME AS C1			
A3A5C4	SAME AS A2A1C8			
A3A5C5	SAME AS A2A1C9			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3A5C6	SAME AS A2A1C8			
A3A5C7	SAME AS A2A7C13			
A3A5C8	SAME AS A2A1C14			
A3A5C9 THRU C12	SAME AS A2A1C8			
A3A5J1 THRU J3	SAME AS A2A1J1			
A3A5L1	SAME AS A3A3L1			
A3A5L2 THRU L5	SAME AS A2A1L6			
A3A5Q1	TRANSISTOR SINGER PART NO. 556146-675	2N3641	81349	1
A3A5Q2	SAME AS A3A4Q8			
A3A5Q3 AND Q4	SAME AS A3A4Q9			
A3A5Q5	TRANSISTOR SINGER PART NO. 556146-686	U148	17856	1
A3A5Q6	SAME AS A3A4Q8			
A3A5Q7	SAME AS A3A4Q9			
A3A5R1 AND R2	SAME AS R32			
A3A5R3	SAME AS R50			
A3A5R4	SAME AS A2A3R10			
A3A5R5 AND R6	SAME AS A2A7R4			
A3A5R7	SAME AS R28			
A3A5R8	SAME AS A3A4R48			
A3A5R9 AND R10	SAME AS A2A1R10			
A3A5R11	SAME AS A3A3R25			
A3A5R13	SAME AS A2A1R10			
A3A5R14	SAME AS A2A3R9			
A3A5R15	SAME AS A2A7R4			
A3A5R16	RESISTOR,FIXED,COMP.,2K OHMS PORM 5PCT 1/4W SINGER PART NO. 150-1002-202J	CB2025	01121	1
A3A5R17	RESISTOR,VARIABLE, 5K OHMS,PORM 20 PCT,1/4W SINGER PART NO. 151-0021-005	UHT201-2/5K,20PCT	11236	1
A3A5R18	SAME AS A2A7R25			
A3A5R19 AND R20	SAME AS A2A1R10			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3A5R21	SAME AS A2A7R14			
A4	DEFLECTION AMPLIFIER ASSY	103-1566-001	16665	1
A4C1	CAPACITOR,FIXED,DIPPED MICA, 750 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-751EJ0	DM15E751J0500WV4CR	72136	1
A4C2 THRU C3	SAME AS A2A1C18			
A4C4	SAME AS A4C1			
A4Q1 AND Q2	SAME AS A3A2Q1			
A4Q3	SAME AS A3A4Q9			
A4Q4 AND Q5	SAME AS A3A2Q1			
A4Q6	SAME AS A3A4Q9			
A4Q7	SAME AS A3A5Q1			
A4Q8 AND Q9	TRANSISTOR SINGER PART NO. 556146-673	2N3440	81349	1
A4Q10	SAME AS A3A5Q1			
A4Q11 AND Q12	SAME AS A4Q8			
A4R1	RESISTOR,VARIABLE, 100K OHMS,PORM 20 PCT, 1/4W SINGER PART NO. 151-0021-009	UHT201-2/100K,20PCT	11236	1
A4R2	SAME AS R32			
A4R3	SAME AS R22			
A4R4	SAME AS A3A3R22			
A4R5	SAME AS R22			
A4R6	RESISTOR,FIXED,COMP., 820 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-821J	CB8215	01121	1
A4R7	SAME AS R46			
A4R8	SAME AS R13			
A4R9	SAME AS R25			
A4R10	SAME AS R22			
A4R11	SAME AS A3A3R22			
A4R12	SAME AS R28			
A4R13	SAME AS R22			
A4R14	SAME AS R46			
A4R15	SAME AS R13			
A4R16	SAME AS A3A3R8			
A4R17	SAME AS A3A3R38			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A4R18	SAME AS A2A1R13			
A4R19 AND R20	RESISTOR,FIXED,COMP., 270 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-271J	CB2715	01121	1
A4R21 AND R22	RESISTOR,FIXED,WIRE-WOUND, 10K OHMS,PORM 5 PCT,10W SINGER PART NO. 556045-003	247E1035	56289	1
A4R23	RESISTOR,FIXED,COMP., 20K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-203J	CB2035	01121	1
A4R24	SAME AS A3A2R2			
A4R25	SAME AS R19			
A4R26 AND R27	SAME AS A3A3R38			
A4R28 AND R29	RESISTOR,FIXED,COMP., 51K OHMS ,PORM 5 PCT 2W SINGER PART NO. 151-1005-513J	HB5135	01121	1
A4R30	RESISTOR,VARIABLE, 2.5K OHMS,PORM 20 PCT, 1/4W SINGER PART NO. 151-0021-010	UHT201-2/2.5K,20PCT	11236	1
A4R31 AND R32	SAME AS R46			
A5	SAWTOOTH/INTENSFIER ASSY	103-1568-002	16665	1
A5CR1 THRU CR3	SAME AS A2A2CR1			
A5CR4	SAME AS A3A5CR2			
A5CR5 AND CR6	SAME AS A2A2CR1			
A5C1	CAPACITOR,FIXED,DIPPED MICA, 130PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-131EJ0	DM15E131J0500WV4CR	72136	1
A5C2 AND C3	CAPACITOR,FIXED,DIPPED MICA, 110PF,PORM 5 PCT, 500V SINGER PART NO. 150-2002-111EJ0	DM15E111J0500WV4CR	72136	1
A5C4	SAME AS C1			
A5C5	SAME AS A2A1C8			
A5C6	SAME AS A5C1			
A5C7	SAME AS C2			
A5G2	SAME AS A3A2G1			
A5G3	SAME AS A3A5G1			
A5G4 AND Q5	SAME AS A3A4G2			
A5G6	SAME AS A3A4G9			
A5G7	SAME AS A3A5G1			
A5Q8 AND Q9	SAME AS A4G8			
A5Q10 THRU Q12	SAME AS A3A4G2			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A5Q13 AND Q14	SAME AS A3A4Q9			
A5Q15	TRANSISTOR SINGER PART NO. 556146-670	2N1480	81349	1
A5Q16	TRANSISTOR SINGER PART NO. 556146-929	2N2945	81349	1
A5Q17	SAME AS A3A4Q9			
A5Q18	SAME AS A3A5Q1			
A5Q19 THRU Q28	SAME AS A3A4Q2			
A5Q29	TRANSISTOR SINGER PART NO. 153-0001-001	2N5306	81349	
A5Q30	SAME AS A3A4Q9			
A5Q31 THRU Q33	SAME AS A3A4Q2			
A5Q34 AND Q35	SAME AS A5Q29			
A5Q36 THRU Q39	SAME AS A3A4Q2			
A5Q40	SAME AS A3A4Q9			
A5R2	SAME AS R19			
A5R3	SAME AS A2A3R9			
A5R4	SAME AS A2A1R6			
A5R5	SAME AS A3A1R10			
A5R6	SAME AS R28			
A5R7	SAME AS R19			
A5R8	SAME AS A3A3R8			
A5R10	SAME AS A2A7R15			
A5R11	SAME AS R19			
A5R12	SAME AS A3A3R18			
A5R13	SAME AS R22			
A5R14	SAME AS A4R6			
A5R15	SAME AS A2A3R9			
A5R16	RESISTOR,FIXED,COMP., 47K OHMS,PORM 5 PCT,2W SINGER PART NO. 151-1005-473J	HB4735	01121	1
A5R17	RESISTOR,FIXED,COMP., 30K OHMS PORM 5PCT 5W SINGER PART NO. 151-2002-303J	5XM30000	63743	1
A5R18	SAME AS R19			
A5R19	SAME AS A2A7R4			
A5R20	SAME AS R19			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A5R21	SAME AS A2A1R10			
A5R22	SAME AS A4R23			
A5R23 AND R24	SAME AS R24			
A5R25	SAME AS A2A1R10			
A5R26	SAME AS A4R23			
A5R27	SAME AS R19			
A5R28	SAME AS A3A3R38			
A5R29	SAME AS R19			
A5R30	SAME AS A3A4R3			
A5R31	SAME AS R19			
A5R32	SAME AS A3A1R10			
A5R33	SAME AS A3A3R8			
A5R34	SAME AS R19			
A5R35	RESISTOR,FIXED,COMP., 3600 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-362J	CB3625	01121	1
A5R36	SAME AS A2A7R4			
A5R37	SAME AS A3A4R48			
A5R38	SAME AS R19			
A5R39 AND R40	SAME AS R13			
A5R41	SAME AS A2A7R15			
A5R42	SAME AS R19			
A5R43 AND R44	SAME AS R13			
A5R45	SAME AS A2A7R15			
A5R46 AND R47	SAME AS R19			
A5R48 AND R49	SAME AS R13			
A5R50	SAME AS A2A7R15			
A5R51 THRU R53	SAME AS R13			
A5R54	SAME AS A2A7R15			
A5R55	SAME AS R19			
A5R56 AND R57	SAME AS R13			
A5R58	SAME AS A2A7R15			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A5R59	SAME AS R19			
A5R60	SAME AS R13			
A5R61	SAME AS R19			
A5R62	SAME AS A2A7R15			
A5R63	SAME AS R19			
A5R64	SAME AS R13			
A5R65	SAME AS A2A7R15			
A5R66	SAME AS R13			
A5R67	SAME AS A2A7R15			
A5R68	SAME AS R19			
A5R69 THRU R71	SAME AS R13			
A5R72	SAME AS A2A7R15			
A5R73	SAME AS R19			
A5R74 AND R75	SAME AS R13			
A5R76	SAME AS A2A7R15			
A5R77	SAME AS R19			
A5R78	SAME AS A2A3R9			
A5R79	SAME AS R22			
A5R80	SAME AS A2A7R25			
A5R81	SAME AS R19			
A5R82	RESISTOR,FIXED,COMP., 4300 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-432J	CB4325	01121	1
A5R83	SAME AS R50			
A5R84	SAME AS A2A7R15			
A5R85	SAME AS R19			
A5R86	SAME AS R13			
A5R87	SAME AS A2A7R15			
A5R88	SAME AS R19			
A5R89	RESISTOR,FIXED,COMP., 100K OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-104J	EB1045	01121	1
A5R90	SAME AS A2A3R9			
A5R91	SAME AS A2A7R3			
A5R92	SAME AS R28			
A5R93	SAME AS A2A3R9			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A5R94	SAME AS R28			
A5R95	SAME AS A4R30			
A5R96	SAME AS R28			
A5R97	SAME AS R19			
A5R98	SAME AS A5R82			
A5R99	SAME AS R50			
A5R100	SAME AS A2A7R15			
A5R101	SAME AS R19			
A5R102	SAME AS A2A1R10			
A5R103	SAME AS A2A3R9			
A5R104	SAME AS A5R35			
A5R105	SAME AS R35			
A5R106	RESISTOR,FIXED,COMP., 5600 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-562J	CB5625	01121	1
A5R107	SAME AS R32			
A5R108	SAME AS A2A3R9			
A5R109	SAME AS R51			
A5R110	RESISTOR,FIXED,COMP., 43K OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-433J	CB4335	01121	1
A5R111	RESISTOR,FIXED,COMP., 68K OHMS,PORM 5 PCT, 1W SINGER PART NO. 151-1004-683J	CB6835	01121	1
A5R112	SAME AS A5R106			
A6	CRT POWER SUPPLY ASSY	103-1567-002	16665	1
A6CR1 THRU CR3	SAME AS A3A1CR1			
A6CR4 THRU CR9	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556118-179	EH-300	83701	1
A6C1	CAPACITOR,FIXED,ELECTROLYTIC, 250 UF,PLUS 50 MINUS 10 PCT, 30V SINGER PART NO. 556201-102	39D257G030EL4	56289	1
A6C2 AND C3	CAPACITOR,FIXED,ELECTROLYTIC, 50 UF,PLUS 75 MINUS 10 PCT,15V SINGER PART NO. 150-5001-500DS	30D506G015DB4	56289	1
A6C4	SAME AS A2A1C8			
A6C5	CAPACITOR,FIXED,ELECTROLYTIC, 2 UF,PLUS 75, MINUS 10 PCT,15V SINGER PART NO. 150-5001-2R0DS	TE-1148	56289	1
A6C6 AND C7	CAPACITOR,FIXED,DIPPED MYLAR,0.0075 UF,100V SINGER PART NO. 556147-200	1DP-1-752	72136	1
A6C8 THRU C11	CAPACITOR,FIXED,CERAMIC, 0.01 UF,PORM 20 PCT 3000V SINGER PART NO. 150-1006-001	41C121A2	56289	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A6C12	CAPACITOR,FIXED,CERAMIC DISC, 0.003 UF,GMV 1000V SINGER PART NO. 556146-697	DD302	71590	1
A6C13 THRU C18	SAME AS A6C8			
A6C19	CAPACITOR,FIXED,CERAMIC DISC, 0.05 UF,PLUS 80,MINUS 20 PCT,500V SINGER PART NO. 556074-055	33C58	56289	1
A6C20 AND C21	SAME AS A6C8			
A6C22 AND C23	CAPACITOR,FIXED 25PF 3KV SINGER PART NO. 556147-223	DD30-250	71590	1
A6C24 AND C25	CAPACITOR,FIXED,DIPPED MICA, 200 PF, PORM 5 PCT, 500V SINGER PART NO. 150-2002-201FJ0	DM15F201J0500WW4CR	72136	1
A6L1 AND L2	CHOKE,RF, 0.5MH SINGER PART NO. 556146-700	670-2	04213	1
A6Q1 AND Q2	TRANSISTOR SINGER PART NO. 556147-198	2N4922	81349	1
A6Q3	TRANSISTOR SINGER PART NO. 556147-197	2N4870	81349	1
A6R1	RESISTOR,FIXED,COMP., 1MEGOHM,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-105J	CB1055	01121	1
A6R2	RESISTOR,FIXED,COMP., 200K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-204J	CB2045	01121	1
A6R3 AND R4	RESISTOR,FIXED,COMP., 1.5 K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-152J	EB1525	01121	1
A6R5	THERMISTOR, 12 OHMS SINGER PART NO. 556146-901	B1204H	10646	1
A6R6	RESISTOR,FIXED,COMP., 220K OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-224J	EB2245	01121	1
A6R7	RESISTOR,FIXED,WIRE-WOUND, 25 MEGOHM,PORM20 PCT,1W SINGER PART NO. 556146-911	MVX/25MEGPORM20PCT1W	75042	1
A6R8	RESISTOR,FIXED,COMP., 15K OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-153J	EB1535	01121	1
A6R9	RESISTOR,FIXED,COMP., 220K OHM,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-224J	CB2245	01121	1
A6R10	SAME AS A6R7			
A6R11	RESISTOR,FIXED,COMP., 1 MEGOHM ,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-105J	EB1055	01121	1
A6R12	RESISTOR,FIXED,COMP.,10K OHMS PORM 5PCT 1/2W SINGER PART NO. 151-1003-103J	EB1035	01121	1
A6R13 AND R14	RESISTOR,FIXED,COMP., 2.2MEGOHM,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-225J	EB2255	01121	1
A6R15 AND R16	RESISTOR,FIXED,COMP.,62K OHMS PORM 5PCT 1/2W SINGER PART NO. 151-1003-623J	EB6235	01121	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A6T1	TRANSFORMER	132-0270-001	16665	1
A7	POWER SUPPLY RECTIFIER AND FILTER ASSY	103-1570-001	16665	1
A7CR1 AND CR2	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556118-106	MV-10C	13327	1
A7CR3 THRU CR12	SEMICONDUCTOR DEVICE.DIODE SINGER PART NO. 556146-689	1N4089	81349	2
A7C1 AND C2	CAPACITOR,FIXED,ELECTROLYTIC, 50 UF,PLUS 75, MINUS 10 PCT,450V SINGER PART NO. 556201-105	39D506F450JP4	56289	1
A7C3	CAPACITOR,FIXED,ELECTROLYTIC, 130 UF,PLUS 50 MINUS 10 PCT,200V SINGER PART NO. 556201-104	39D137F200HL4	56289	1
A7C4 THRU C7	CAPACITOR,FIXED,ELECTROLYTIC, 2400 UF,PLUS 50,MINUS 10 PCT,30V SINGER PART NO. 556201-103	39D248G030JP4	56289	1
A7F1	FUSE,DELAY, 1/10 AMPS SINGER PART NO. 556146-887	MDL1/10	71400	5
A7F2	FUSE,DELAY, 2 AMP SINGER PART NO. 556006-021	313002	75915	3
A7F3	FUSE,DELAY, 1.25 AMPS SINGER PART NO. 556146-743	MDX1-1/4	71400	3
A7R1	RESISTOR,FIXED,WIRE-WOUND, 700 OHMS,PORM 5 PCT,5W SINGER PART NO. 556043-009	243E7015	56289	1
A7R2	REISTOR,FIXED,COMP., 560K OHMS ,PORM 5 PCT, 1W SINGER PART NO. 151-1004-564J	GB5645	01121	1
A7R3	RESISTOR,FIXED,COMP., 100K OHMS,PORM 5 PCT, 1W SINGER PART NO. 151-1004-104J	GB1045	01121	1
A7R4 AND R5	SAME AS R51			
A7XF1 THRU XF3	CLIP,FUSE SINGER PART NO. 556146-716	6008-32A	91506	1
A8	POWER SUPPLY CONTROL ASSY	103-1569-001	16665	1
A8CR1 AND CR2	SAME AS A7CR3			
A8CR3	SAME AS CR1			
A8CR4 AND CR5	SAME AS A7CR3			
A8CR6	SAME AS CR1			
A8C1	SAME AS A7C3			
A8C2	SAME AS C1			
A8C3	SAME AS A2A1C9			
A8C4	CAPACITOR,FIXED,ELECTROLYTIC, 4 UF,PLUS 75 MINUS 10 PCT,150V SINGER PART NO. 150-5001-4ROHS	30D405G150DD4	56289	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A8C5	CAPACITOR,FIXED,ELECTROLYTIC, 1 UF,PLUS 75, MINUS 10 PCT,25V SINGER PART NO. 150-5001-1R0ES	TE-1200	56289	1
A8C6 AND C7	CAPACITOR,FIXED,ELECTROLYTIC, 200 UF,PLUS 50 MINUS 10 PCT,25V SINGER PART NO. 556201-101	39D207G025EJ4	56289	1
A8C8	SAME AS A8C5			
A8C9 AND C10	SAME AS A8C6			
A8C11 AND C12	SAME AS C1			
A8Q1 THRU Q4	SAME AS A4Q8			
A8Q5	SAME AS A3A4Q9			
A8Q6 AND Q7	SAME AS A3A2Q1			
A8Q8	SAME AS A3A4Q9			
A8Q9 AND Q10	SAME AS A3A2Q1			
A8R1	SAME AS R32			
A8R2	SAME AS A3A2R2			
A8R3	SAME AS A2A1R1			
A8R4	SAME AS A3A4R3			
A8R5	RESISTOR,FIXED,COMP., 3.3 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-3R3J	CB3R35	01121	1
A8R6	SAME AS A2A1R1			
A8R7	RESISTOR,FIXED,COMP., 39K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-393J	CB3935	01121	1
A8R8	SAME AS A2A1R1			
A8R9	RESISTOR,FIXED,COMP., 2700 OHM,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-272J	CB2725	01121	1
A8R10	SAME AS A3A5R17			
A8R11	RESISTOR,FIXED,COMP., 15K OHMS ,PORM 5 PCT, 1W SINGER PART NO. 151-1004-153J	GB1535	01121	1
A8R12	RESISTOR,FIXED,COMP., 560 OHMS ,PORM 5 PCT, 1W SINGER PART NO. 151-1004-561J	GB5615	01121	1
A8R13	SAME AS A2A4R1			
A8R14	SAME AS A3A3R38			
A8R15	SAME AS A2A1R1			
A8R16	SAME AS R46			
A8R17	SAME AS A2A1R1			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A8R18	SAME AS A3A3R8			
A8R19	SAME AS A2A7R14			
A8R20	SAME AS A8R9			
A8R21	SAME AS A8R12			
A8R22	SAME AS A2A4R1			
A8R23	SAME AS A3A3R38			
A8R24	SAME AS A2A1R1			
A8R25	SAME AS R46			
A8R26	SAME AS A2A1R1			
A8R27	SAME AS A3A3R18			
A8R28	SAME AS A2A7R14			
A8R29	SAME AS A8R9			
A8V1	LAMP,NEON,GLOW SINGER PART NO. 556146-578	Z82R7	74276	1
A9	AUXILIARY CONTROL ASSY	103-1574-002	16665	1
A9C1	CAPACITOR,FIXED 0.05UF 500V SINGER PART NO. 556074-055	33C58	56289	1
A9C2 AND C3	CAPACITOR,FIXED,CERAMIC DISC, 0.01 UF, PORM 20 PCT,200V SINGER PART NO. 556060-084	805-200V-Z5U-103M	72982	1
A9Q1 AND	SAME AS A3A5Q1			
A9Q3 AND Q4	SAME AS A3A4Q9			
A9Q5 AND Q6	SAME AS A3A5Q1			
A9Q7 AND Q8	SAME AS A3A4Q9			
A9Q9	SAME AS A2A1Q1			
A9Q10	SAME AS A3A5Q10			
A9R1	SAME AS R23			
A9R2	SAME AS A4R23			
A9R3	SAME AS R22			
A9R4	SAME AS A3A3R17			
A9R5	SAME AS R50			
A9R6	RESISTOR,FIXED,COMP., 100 OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-101J	EB1015	01121	1
A9R7	SAME AS R28			
A9R8	SAME AS A3A5R17			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A9R9	SAME AS A3A3R18			
A9R10	SAME AS R22			
A9R11	SAME AS A2A7R22			
A9R12	SAME AS R22			
A9R13	SAME AS A4R23			
A9R14	SAME AS R50			
A9R15	SAME AS R28			
A9R16	SAME AS A9R6			
A9R17	SAME AS A2A7R25			
A9R18 AND R19	RESISTOR,VARIABLE, 500K OHMS,PORM 20 PCT, 1/4W SINGER PART NO. 151-0021-012	UHT201-2/500K,20PCT	11236	1
A9R20	SAME AS A4R1			
A9R21	SAME AS A3A5R17			
A9R22	SAME AS R22			
A9R23	RESISTOR,FIXED,COMP.,24K OHMS PORM 5PCT 1/4W SINGER PART NO. 151-1002-243J	CB2435	01121	1
A9R24	SAME AS A4R1			
A9R25	SAME AS A2A7R7			
A9R26	SAME AS A3A3R22			
A9R27	SAME AS A9R18			
A9R28	RESISTOR,FIXED,COMP., 470K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-474J	CB4745	01121	1
A9R29	SAME AS A3A3R8			
A9R30 AND R31	SAME AS R28			
A9R32	SAME AS R50			
A9R33	SAME AS A3A3R18			
A9R34	SAME AS R22			
A9R35	SAME AS R23			
A9R36	SAME AS R50			